Wednesday, September 09, 2015
3:30 PM

Physics 11

Welcome

Course Outline/introduction

Getting to know you

What is Physics?

What is Physics?

Monday, September 14, 2015
8:42 AM

Measurement

Physics is an experimental discipline therefore all hypotheses are tested through observation. Observations are quantified by measurement. Measurement is just comparing an observation to a standardized value.

Metric system, SI

base units:	derived units:
length: metre, m	cm, km,
time: seconds, s	hours, years
Temperature: Kelvin,K	Celsius, C
Mass: kilogrom, kg	g,
Volume:	litres, l, ml=cm^3 1000 000 cm^3 = 1 m^3
Energy:	Joules, J
Force:	Newton, N

For large or small values we either give the value in scientific notation or use prefixes.

923845 m = 9.23845 x 10^5 m = 923.845 km = 0.923845 Mm

Prefixes	Power of ten		
deca, de	10	deci, d	10^{-1}
hecta, h	10^{2}	centi, c	10^{-2}
kilo, k	10^{3}	milli, m	10^{-3}
Mega, M	10^{6}	micro, μ	10^{-6}
Giga, G	10^{9}	nano, n	10^{-9}
Tera, T	10^{12}	pico, p	10^{-12}
peta, P	10^{15}	femto, f	10^{-15}

Converting units using a unit fraction:

how many seconds are in a year?

to solve a more complicated unit conversion, you can multiply the value by a unit fraction, a fraction with the top and bottom values being equivalent.

1 year (365.25 days/year)(24 hrs/day)(60min/hr)(60s/min)

=365.25x24x60x60= 31557600 s in a year

speed limit is 50 km/hr conver that to m/s.

Measurement
SI system, prefixes, unit fractions, Lab outside

Physics:
What is physics?
Study of matter and energy/forces.
Fundamental science - underlying Laws of Nature.
Experimental discipline so hypotheses are tested against observation. We quantify observation with measurement - comparing observations to a standardized unit system.

Metric system, SI system

Base units:	derived units:
length: metre, m	km, cm, light year,
time: second, s	minute, min - hr, year
mass: kilogram, kg	g, ton,
area:	cm^2
volume:	litre, ml=cm^3 $1000000cm^3=1m^3$
electric current: Ampère, A	
electric charge,	Coulomb, or elementary charge
energy:	Joule, J

If you are dealing with really small or really big values, you either put it in scientific notation or use a prefix.

eg. the radius of the earth is 6 380 000 m
6.38×10^6m
or 6 380 km
6.38 Mm

Prefixes	Power of ten		
deca, de	10	deci, d	10^{-1}
hecta, h	10^2	centi, c	10^{-2}
kilo, k	10^3	milli, m	10^{-3}
Mega, M	10^6	micro, μ	10^{-6}
Giga, G	10^9	nano, n	10^{-9}
Tera, T	10^{12}	pico, p	10^{-12}
peta, P	10^{15}	femto, f	10^{-15}

How many seconds in a year?

How fast is 50 km/h in m/s?

Unit conversions using unit fractions:

to convert a value from one unit to another, to make sure you get it the right way, multiply by a unit fraction so that the old unit cancels out.

a unit fraction has the same value but different units in the numerator and denominator.

eg.

1 year(365.25d/y)(24h/d)(60min/h)(60s/min)

unit fraction

365.25d = 1y

= 365.25x24x60x60=31,557,600 s in one year

3.16×10^7s

50 km/h (1000m/km)(h/3600s)

50x1000/3600=13.8889

14m/s

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Converting units Worksheets
Accuracy, Precision - Significant Digits - Lab sheet

nm = 10^{-9}m

eg. You walk 7.2 m in 3.1s. What is your speed in
a) m/s b) km/h c) light years/s d) nm/s

a) 7.2m/3.1s = 7.2/3.1=2.3226 =2.3m/s
b) 2.3226 m/s (km/1000m) (3600s/hr)
2.3226/1000x3600=8.3614 =8.4km/h
c) 1 light year = 3.0×10^8m/s x 1year(365.25d/y)(24h/d)(3600s/h)
300000000x365.25x24x3600=9.47E15
9.47×10^{15}m = 1 light year
2.3226 m/s (1 light year/9.47×10^{15}m)
= 2.3226/9.47×10^{15}=2.452×10^{-16} =
2.5×10^{-16}lightyears/s

d) 2.3226 m/s (1nm/10^{-9}m)
=2.3×10^9nm/s

Accuracy and Precision

All measurements are limited in accuracy and precision by the equipment, your use of the equipment or

Heisenberg's uncertainty principle (you can't know position and momentum infinitely precisely)

Accuracy: Your measurement is dead on the real value. (like hitting a bulls eye with an arrow).
quantify the accuracy of a lab by calculating the
%error = |experimental - theoretical|/theoreticalx100%

eg. you measure the density of a block of aluminum at $2.2 g/cm^3$ but the theoretical value (in the book) is $2.70 g/cm^3$. What is your % error?

%error = |experimental - theoretical|/theoreticalx100%
$= |2.2 g/cm^3 - 2.70 g/cm^3| / 2.70 g/cm^3 \times 100\% =$
2.2-2.7=-0.5
$0.5/2.7 = 0.1852 = 19\%$ error $= 2 \times 10^1\%$ error

Precision - If you repeat a measurement, how close are the values to each other? Closer= more precise.
- like shoot arrows, and they are all bunched together it is precise.

but not precise accurate

Quantify precision -

1. repeat a measurement and see the range of uncertainty. eg. 2.40cm, 2.63cm, 2.50cm
   range of uncertainty is +/-0.1cm so you should give the value as
   2.5 +/-0.1cm
   implied in 2.5cm, the number of digits implies the uncertainty
2. smallest division on the device.
   eg. ruler measures to the mm, +/- 0.5mm
   stopwatch measures to the hundredth, +/-0.01s
3. estimate it from your assessment of factors of the apparatus.
   eg. stopwatch, students reaction time is about 0.1s, so uncertainty is +/- 0.1s

Significant figure rules:
All measurements have a limited number of digits implying the precision.

is 2.0s different than 2 s or 2.00s?
they have different uncertainties implied

rules for sig figs, all non-zero digits are significant.

3.32 has 3 sig figs
443.4 has 4 sig figs

zeros in the middle or after a sig fig and after a decimal are significant
303 has 3
2.00 has 3 sig figs

but zeros used for place value are not significant

0.0000020 has 2 sfs
count

3.0×10^7 has 2 sf

300 has assume 1
unclear ?

3.0×10^2
3×10^2

Rules:

Multiplying and Dividing Measured Values.

Round your answer to the lowest number of significant digits of the starting values.

eg. 1.0 x 2.7050 = 2.705 = 2.7

2 sfs 5 sfs

Adding/subtracting rule:

Round your answer to least precise decimal place of the starting values.

eg. 12.502 - 9.6

$$\begin{array}{r} 12.502 \\ 9.6 \\ \hline 2.902 \end{array} = 2.9$$

12.502 - 12.1 = 0.402 → 0.4

Converting units Work

Accuracy, Precision - Significant Digits

Traffic Lab
say that you paced off 7.2m and someone ran it in 2.1s. Determine the speed in
a) m/s b)km/h c)light years/s d)nm/s

a) v=d/t = 7.2m /2.1s 7.2/2.1=3.4286 = 3.4 m/s
b) 3.4286 m/s (km/1000m)(3600s/h)
3.4286/1000x3600=12.343 =12km/h
c) $v=3.0\times10^{8}$m/s 3E8 or 3EXP 8
$d=vt = 3\times10^{8}$m/s(1y)(365.25d/y)(24h/d)(3600s/h)
300000000x365.25x24x3600=9.47E15
9.47×10^{15}m = 1 light year
3.4286 m/s (1lightyear/9.47×10^{15}m)
3.4286/(9.47×10^{15}) = 3.6×10^{-16} light year/s

d) 3.4286 m/s (nm/10^{-9}m)
3.4×10^{9} nm/s

Accuracy and Precision

Accuracy - How close to the actual or theoretical value is the measurement?

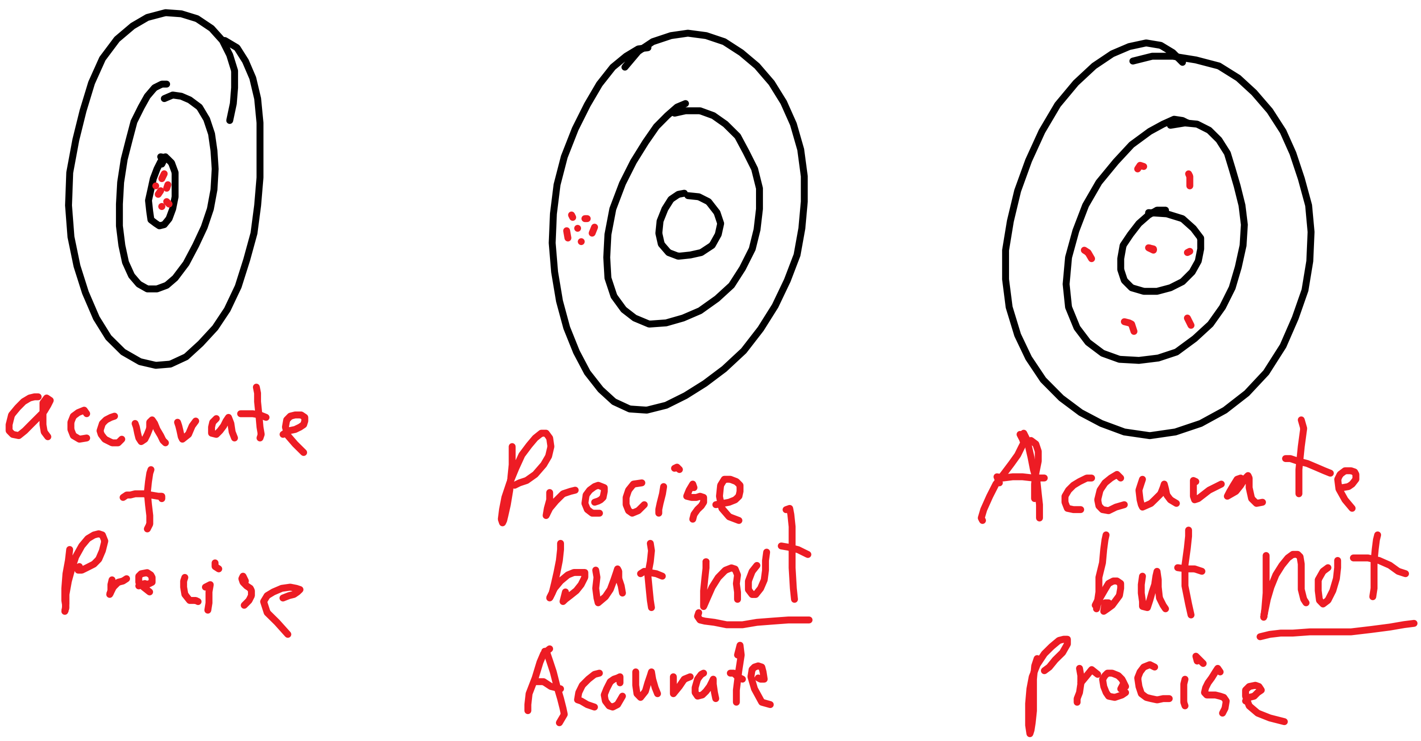
quantify accuracy by the percent error, %error
%error = |experimental-theoretical|/theoreticalx100%

eg. you measure the density of an aluminum block to be 2.2 g/cm^3 while the book value is 2.70g/cm^3. What

is your % error?

%error = |experimental-theoretical|/theoreticalx100%
%error= $|2.2 g/cm^3 - 2.70\ g/cm^3| / 2.70 g/cm^3 \times 100\%$
2.2-2.7=-0.5
0.5/2.7=0.1852 x100% = 19% or 2×10^1%

Precision - if you repeat a measurement, what is the range of values? small range, small uncertainty in the measurement so it is precise.



methods to determine precision:

1. repeat the measurement. The range of values is the uncertainty range and determines the number of digits that are significant.
   eg. you measure the length of a pen at 10.50cm 12.13 cm and 11.32 cm, the range is

12.13-10.50=1.63
uncertainty is +/- 1.63/2=0.815 +/-0.8
11 cm +/- 1cm
or just 11cm because that implies +/-1
if you give the value at 10.50cm you imply +/- 0.01

2. the smallest division on the instrument can be an estimate of the precision.
   eg. rulers measure to the mm, so +/- 1 mm or 0.5mm
3. the uncertainty can be estimated from other factors
   eg. a stopwatch is limited by the reaction time of the user, about 0.1s

Significant Digits Rules:
All measurements are limited in precision by the instrument, the user and Heisenberg's uncertainty principle(atomic level).

All measurements have limited digits that are significant, Sig Figs or Significant digits or figures or SFs.

look at 2s or 2.0s or 2.00s.
They are all the same value but to different precisions.
2s has 1 digit and implies +/- 1s
2.00 has 3 digits implies +/- 0.01s

Rules:

all non zero digits are significant

eg. 343 has 3 sfs

zeros after a significant digit and after the decimal are significant

2.00 has 3 sig figs

zeros between sig figs are significant

eg 303.0 has 4 sig figs

zeros for place values are not significant or are unclear

eg. 0.0000002 has only 1 sig fig, the 2

3000 has ? sig figs, it is unclear. (in Chem they will say 3000 has 1 sig fig)

3×10^3 has 1 sig fig

3.0×10^3 has 2 sig figs

Rules for

Multiplying and dividing:

Round your answer to the least number of sig figs of the numbers you start with.

eg. $1.0 \times 34.89 = 3 \times 10^1$

Adding and subtracting

Round the answer to the least precise decimal place.

eg. 1.0 + 34.89 = 35.89

1.0 ← tenth

hundredth

tenth

$$
\begin{array}{r}
1.0 \\
+\ 34.89 \\
\hline
35.89
\end{array}
$$

34.89 ← hundredth

$35.89 \rightarrow \boxed{35.9}$ ← tenth

Lab Report Guide Sheet

Title, name and partners name labeled
problem or aim or purpose
Hypothesis - statement of how things work that you test.
Procedure or process - Don't copy out procedure, just say "refer to lab manual p__"
but write out any changes

Observations:
table with a title and units
be careful of significant digits - related to uncertainty

Analysis- graph data and find an equation
calculate the %error if you have a testable value

conclusion - State whether the data supports your hypothesis, and how close is it. Never say "prove".

Sources of Uncertainty - factors that influence the validity of the data.

- equipment - ruler has an uncertainty of +/- 1 mm.
- look at the data for support - is the data shifted?

Lab Report Guidelines:

What do you include in a lab report?

Title name and label partner's name
purpose or aim or problem - variables you test.
Hypothesis or theory - statement of how things work that you test.
Procedure - don't copy out the procedure, just write "refer to lab manual p___" but write out your contribution.
Observations -
table with a title and units
be careful of sig figs
quantitative

Analysis-
graph with a derived equation
show sample calculations
calculate %error

Conclusion - Does the data support the

hypothesis? How closely?(%errror)
never say "prove"

Sources of Uncertainty - List factors that limit the validity of the data.
equipment - specify the range of uncertainty
eg. a ruler will measure to the mm
look at the data and see patterns

Graphing Data **to Get an Equation**

http://physics-pages.wikispaces.com/Graphing+tips

What to include in a graph?
Title - describes the experiment, not just v vs t
axes - labels, units and a consistent scale
choose the scale so the data takes up over half the page - gives better precision
data points and a best-fit line (shows the trend of the data - does not connect the dots or necessarily go through the origin. Can be a curve if the data is non-linear.)

If the data is linear
use a ruler to draw the best-fit line, then choose two points on the line, not necessarily data points, far apart that you make a triangle for the rise and run.

slope, m=rise/run - make sure you include units and round to usually 2 or 3 sig figs.

y-intercept, b = point on the y axis where the line hits and x=0. If you offset x data, then input a point on the line into y=mx+b and solve for b.

Last step:
replace every term in y=mx+b to give the equation.

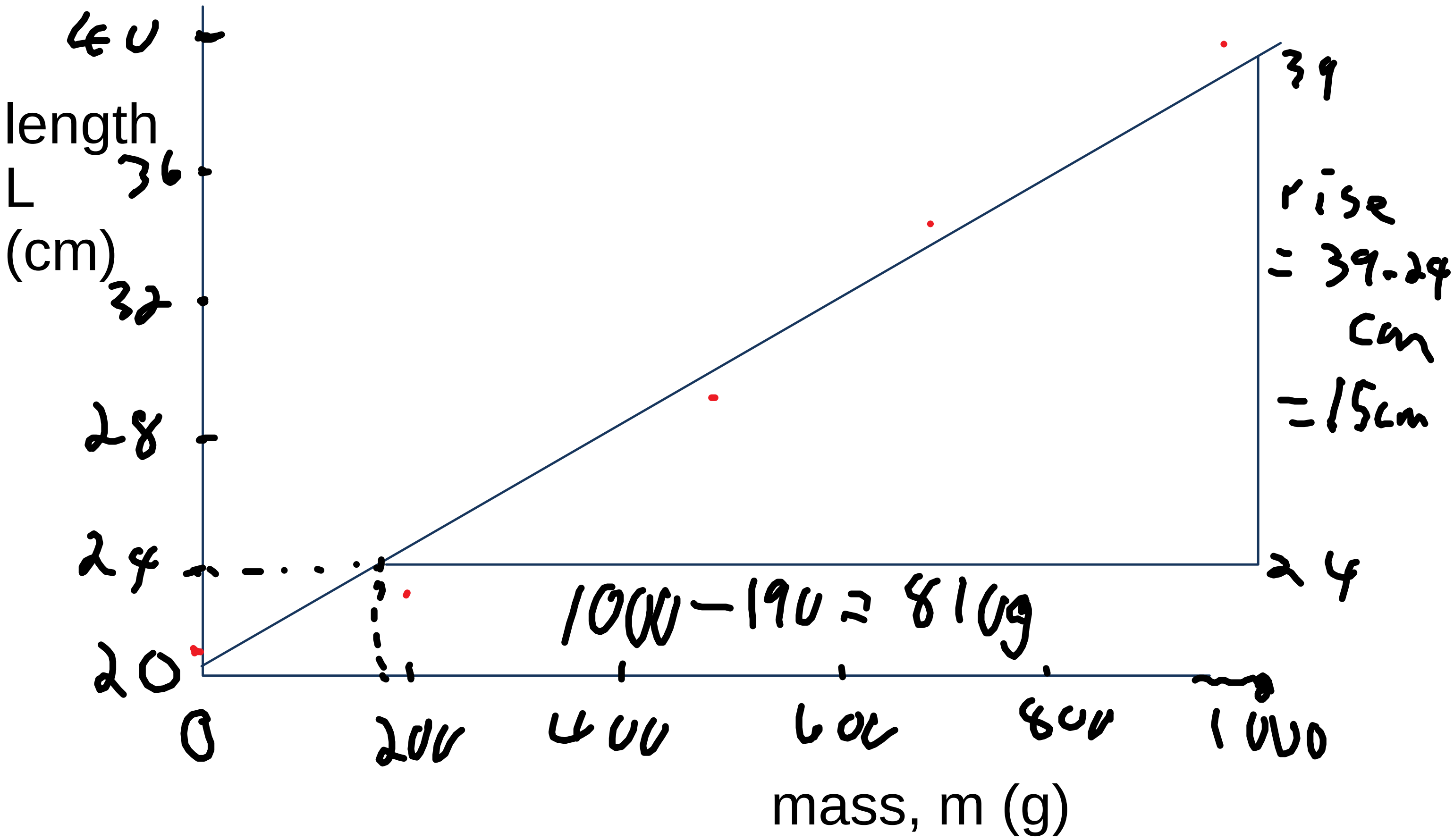
y is the y axis variable, x is the x axis variable, m is slope with units and 2 or 3 sig figs, b is y intercept with units and 2 or 3 sig figs.

eg.
Lets do an experiment, hang masses on a spring and observe the length of the spring.

independent variable goes on the x axis, mass is the independent variable because we control it.

length, cm	mass, g
21.0	0
22.8	200
29.0	500
32.7	700
39.0	1000

title: length of a spring with masses



Slope $m = \frac{rise}{run} = \frac{15cm}{810g}$

Show on graph

m =
15/810=0.0185
m = 0.018 cm/g

y intercept = 20.5 cm = 21 cm
y=mx+b
replace y with the variable on the y axis
L=0.018cm/g m + 21cm

L=0.018cm/g m + 21cm

%error= |exp-theo|/theo x 100%

eg. in the lab your density of aluminum is $2.90 g/cm^3$ but the theoretical value is $2.70 g/cm^3$, determine the % error.

%error= |exp-theo|/theo x 100%

= $|2.90 g/cm^3 - 2.70 g/cm^3|/2.70 g/cm^3$

0.2/2.7=0.0741 = 7.4 %

Graphing Data **to Find an Equation**

title - describes the experiment - not v vs t, try the velocity of a cart rolling down a hill

axes with labels, units and a consistent scale - should be set so the data takes up more than half the page.

plot points - size can show uncertainty

draw a best-fit line - should show the trend of the data, but don't connect the dots, it doesn't have to

touch any of the points or the origin necessarily.
on the graph, draw a triangle from two points on the line far apart.
slope of the line, m= rise/run of the triangle
y-intercept, b= where the lines hits the y-axis at x=0 (if you offset x, then input a point on the line into y=mx+b and solve for b)
values need units and proper sig figs, 2 or 3 depending on how good the data looks.
-Do not leave the slope as a fraction.
sub values and variables into y=mx+b for every term. F=2.0N/m L + 0.12N

eg. Put various masses on a spring and measure the length.

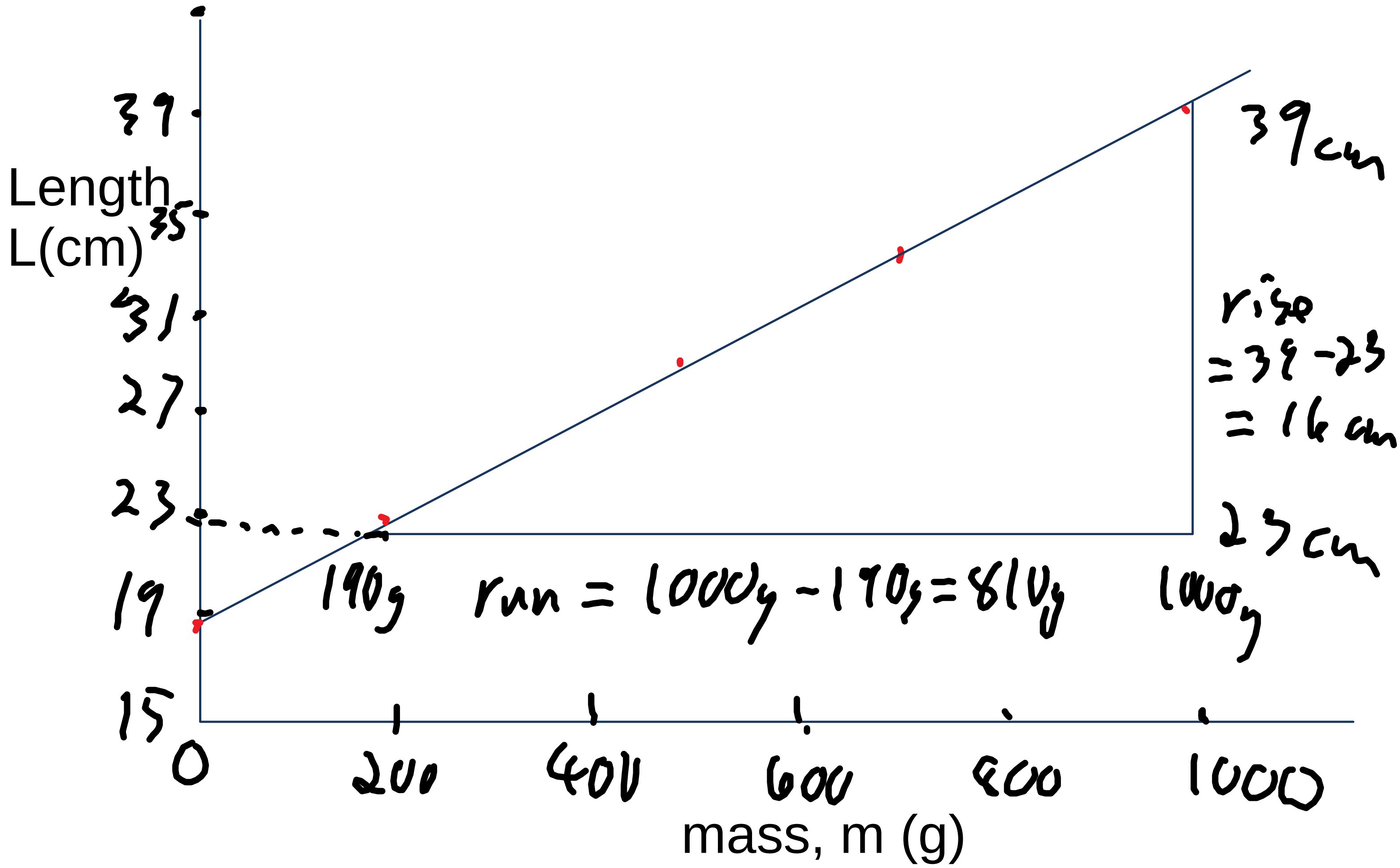
independent variable goes on the x-axis - the one you control - in this case, it is mass

mass(g)	Length(cm)
0	18.8
200	81-58=23.0
500	80.5-52=28.5
700	78.5-46=32.5
1000	78.5-39.7=38.8

graph the data and determine the equation

relating Length to mass.

title: length of a spring with masses on it



$$\text{Slope, } m = \frac{\text{rise}}{\text{run}} = \frac{16\,\text{cm}}{810\,\text{g}}$$

16/810=0.0198 $= \boxed{0.020\ \frac{\text{cm}}{\text{g}}}$ slope

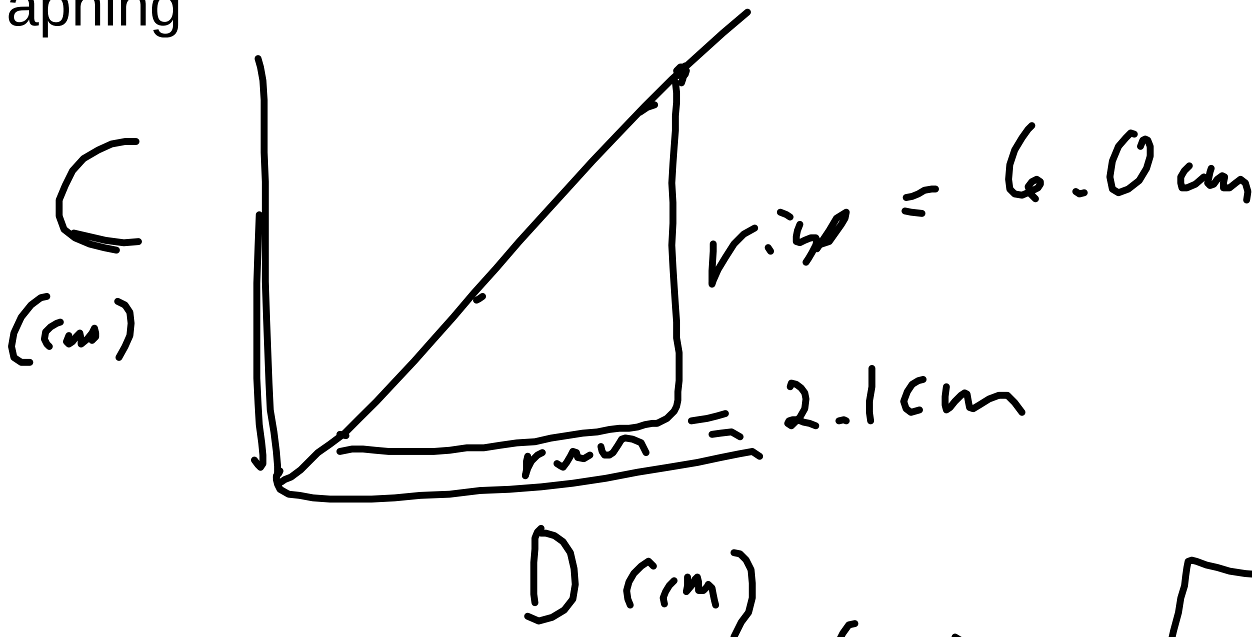
y-int = 19cm

$$y = mx + b$$

* $$L = 0.020 \frac{cm}{g} m + 11 cm$$

Thursday, September 24, 2015
8:42 AM

Quiz review:
unit conversions
sig figs
graphing



$$\text{slope} = \frac{6.0\,\text{cm}}{2.1\,\text{cm}} = \boxed{2.9}$$

$$y = mx + b$$

$$\boxed{C = 2.9D + 0.1\,\text{cm}}$$

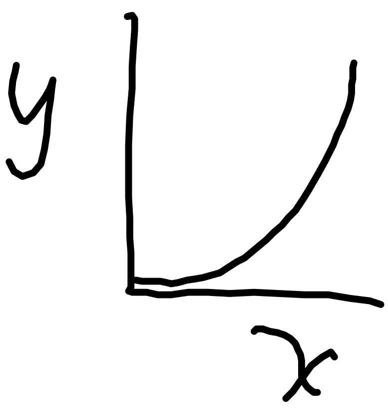
$$V = 4.8\,\frac{m}{s^2} t + -0.2\,m/s$$

$$v = 4.8\,\frac{m}{s^2}\,t + -0.2\,m/s$$

Non Linear Graphing

What if the data displays a non-linear relationship?
How do you get the equation of the relationship?

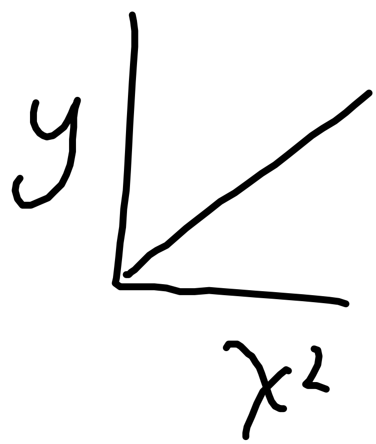
You need to recognize the shape of the graph or the theoretical relationship and transform the data to make it linear. Then get the equation.



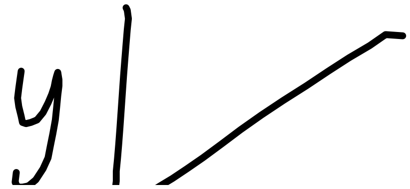
Parabola

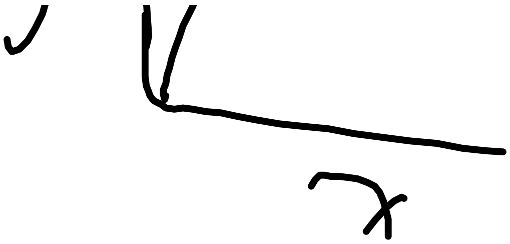
$y \propto x^2$

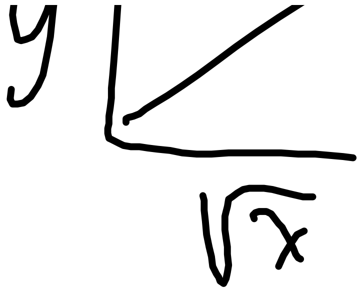
↑ proportional to

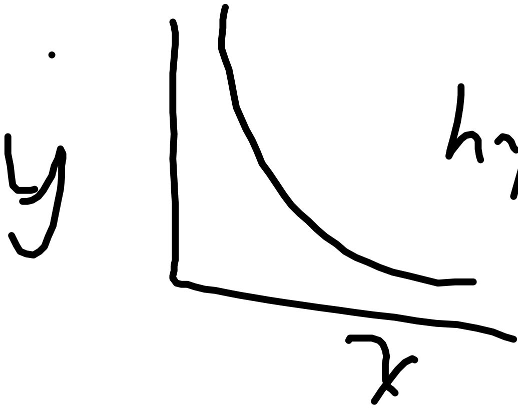


$y = mx^2 + b$





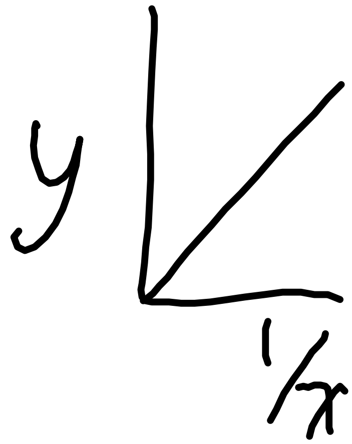




hyperbola

inverse function

$y \propto \frac{1}{x}$



eg. you observe a cart rolling down a hill

distance,d (m)	time (s)
0.0	0.0
1.1	1.0
4.3	2.0
8.7	3.0
15.7	4.0
25.3	5.0

t^2 (s^2)

0

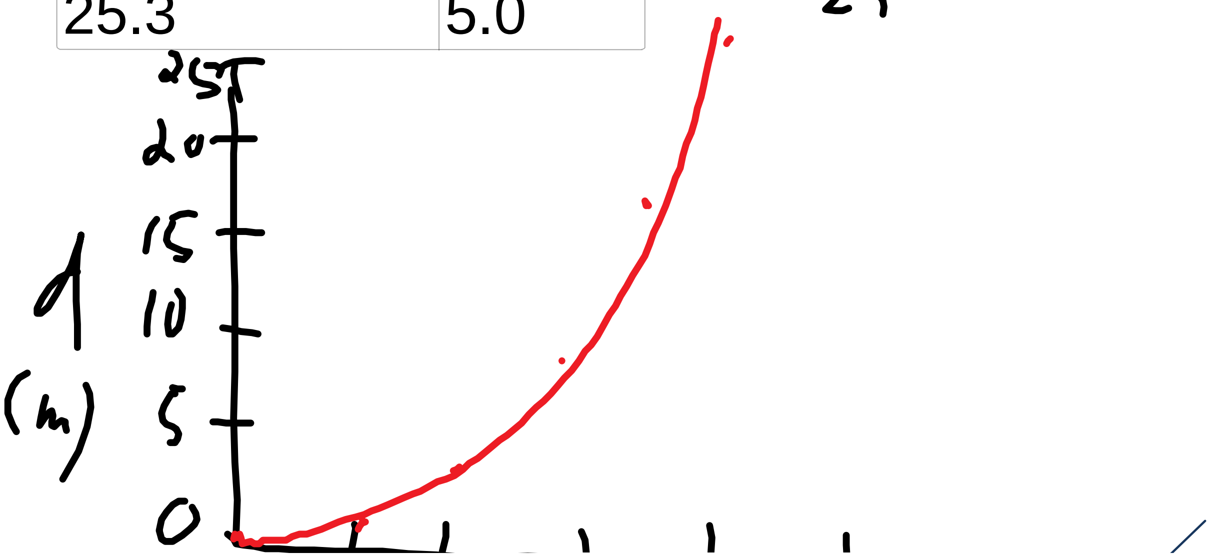
1

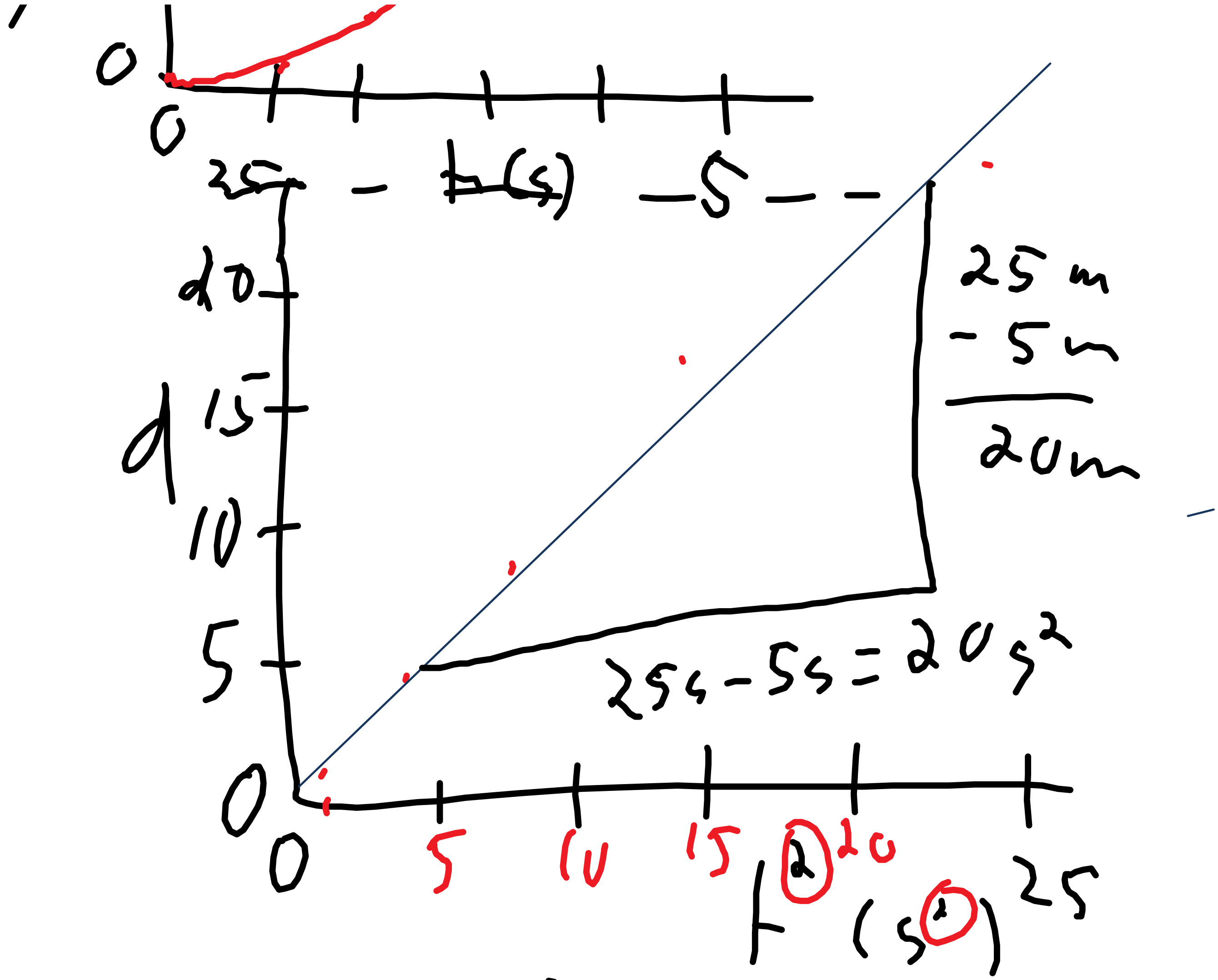
4

9

16

25





$$\text{Slope} = \frac{20\,m}{20\,s^2} = 1.0\,m/s^2$$

$$d = 1.0\,m/s^2\; t^2 + 0.4\,m$$

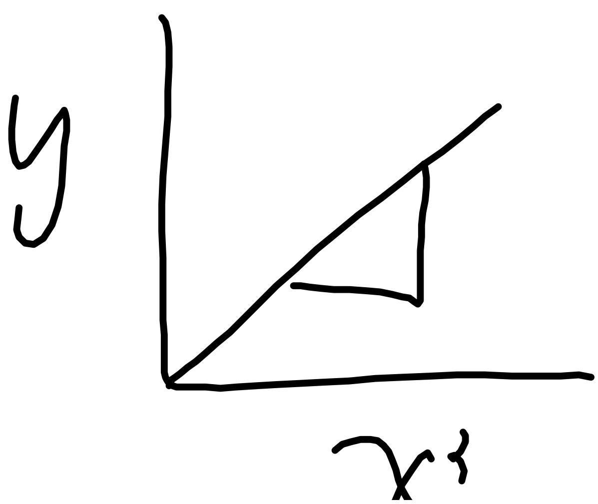
Block 2-2
Graphing Non-Linear Relationships

Remember the purpose of graphing is to get an equation of the relationship.

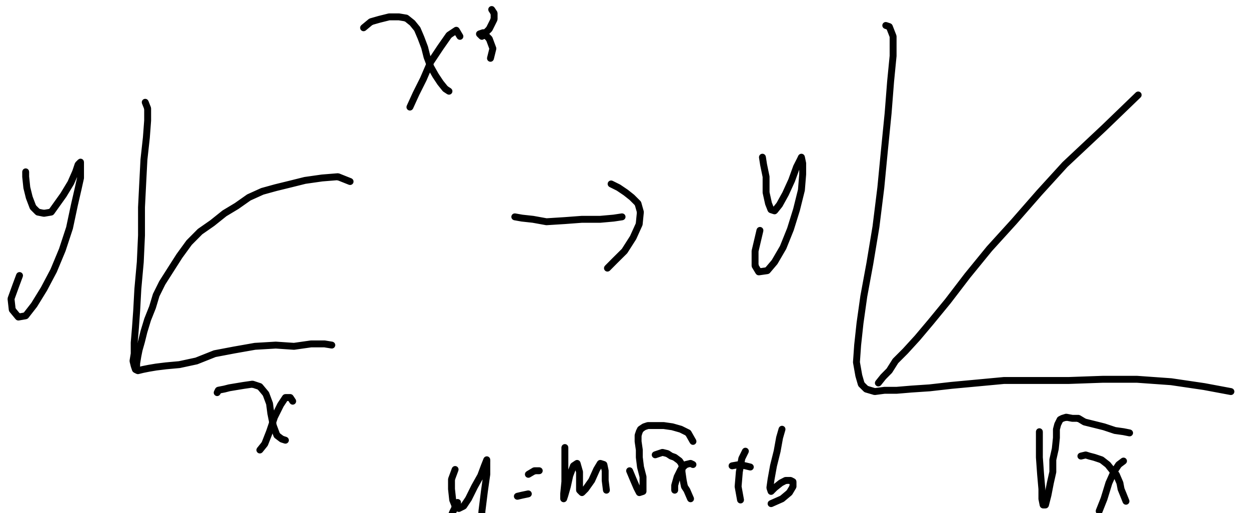
How do you get the equation of this graph:

You recognize the shape of the graph or the theory behind the graph and transform the data to make it linear.

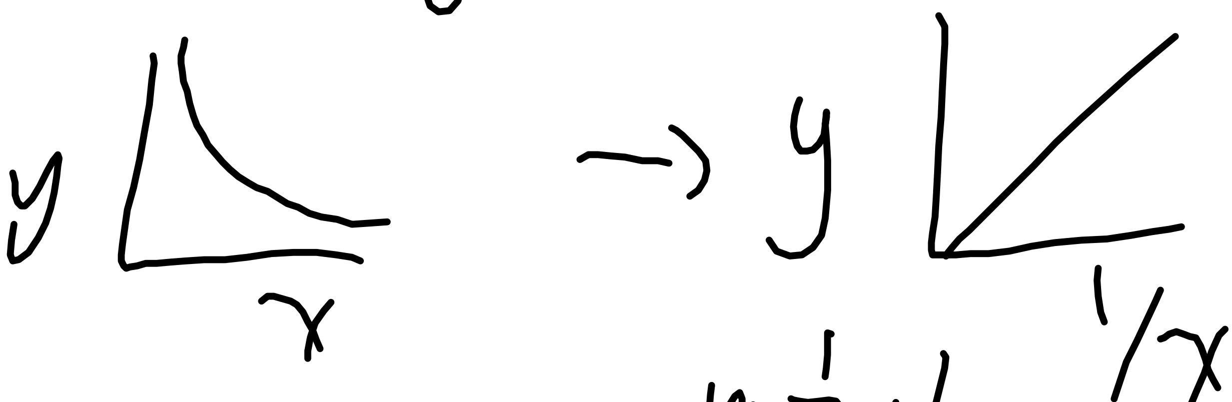
the above graph looks like a parabola, so we say that y is proportional to x^2 or $y=mx^2$
so if you regraph y vs x^2 it should be linear.



$y = mx^2 + b$



$y = m\sqrt{x} + b$



$y = m\frac{1}{x} + b$

a hyperbola, a reciprocal (or inverse) relationship

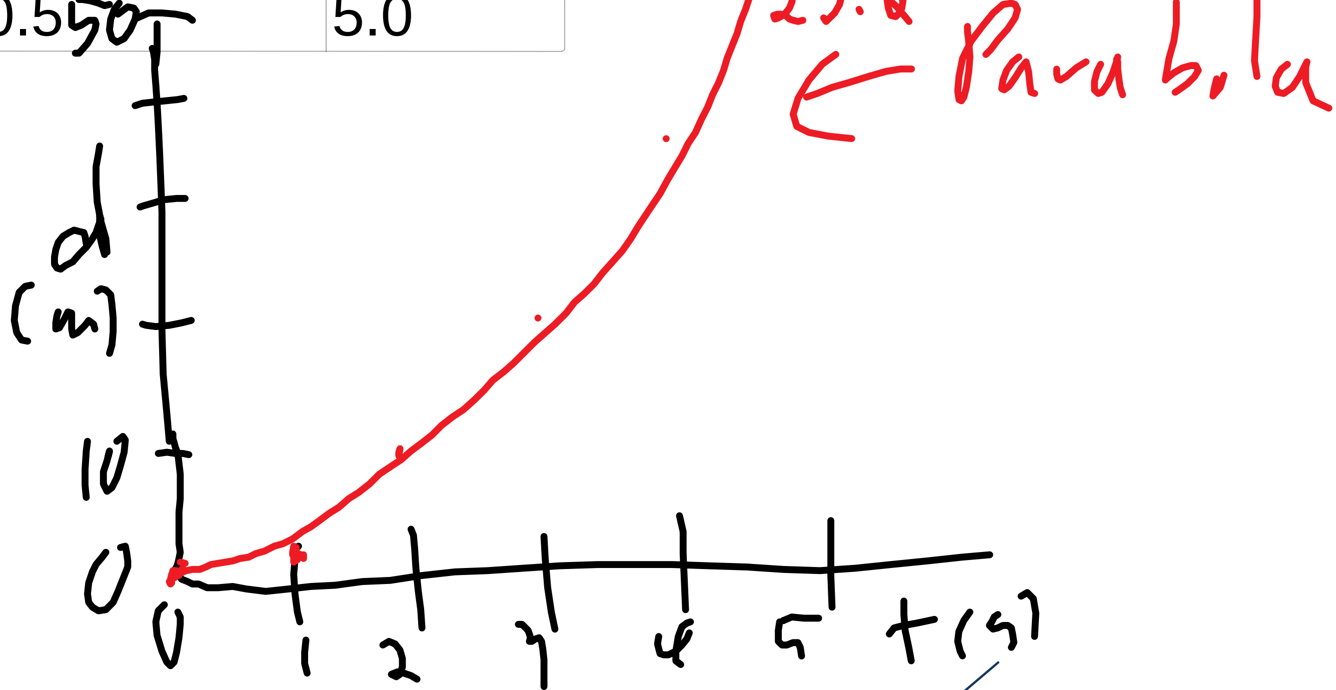
$y \propto \frac{1}{x}$ $\rightarrow$ $y = m\frac{1}{x}$

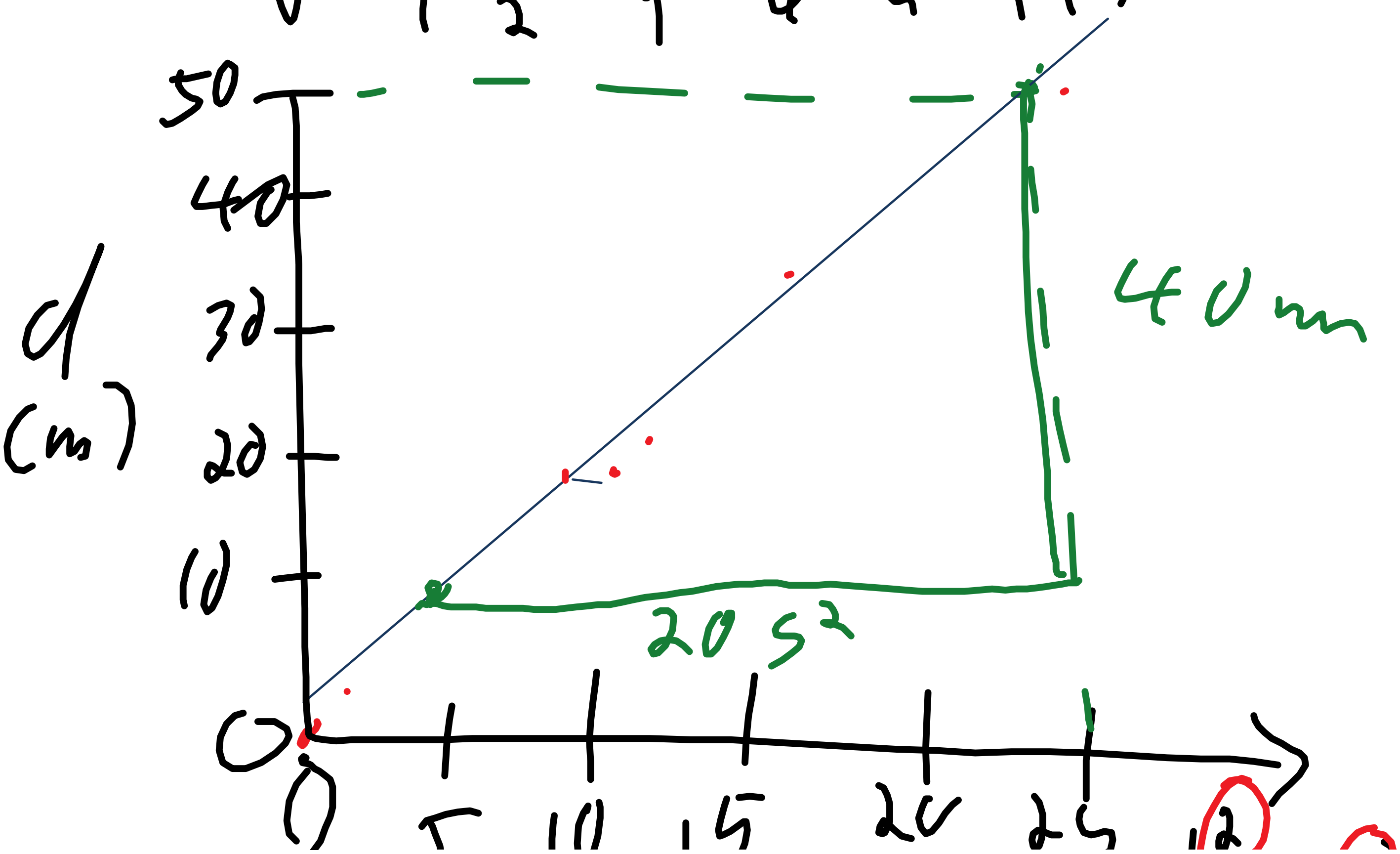
↑ proportional

eg. you get the data of a cart rolling down a slope

distance, d(m)	time, t(s)	$t^2 (s^2)$
0.0	0.0	0.0

distance, d(m)	time, t(s)
0.0	0.0
2.1	1.0
8.3	2.0
18.1	3.0
31.2	4.0
50.5	5.0





0 5 10 15 20 25 $t^2\,(s^2)$

$$\text{slope} = \frac{\text{rise}}{\text{run}} = \frac{40\,m}{20\,s^2} = 2.0\,m/s^2$$

$$y = mx + b$$

$$d = 2.0\,m/s^2\,t^2 + 1\,m$$

Homework: http://physics-pages.wikispaces.com/file/view/Graphing%20tips.pdf/560059391/Graphing%20tips.pdf

6 graphs 1- curve 1-straightened with equation for A vs D, F vs D, λ vs f

Pendulum Lab Name
partner's name

Purpose: determine the relationship between the period of a pendulum and a) the length of the string b) height you drop the bob.

Hypothesis:

a) the equation between period, T and length of a pendulum is:

T= $2\pi \frac{\sqrt{L}}{\sqrt{g}}$

where L is the length of the pendulum (from rotation point to the centre of the bob)

g is the gravitational field strength, 9.80m/s^2.

$\pi\ is\ pi = 3.14159$

b) the higher we drop the bob the___________the period.

Because:

Procedure:

Tie a string on a stand with a weight.

a) change the length of the string, measure the time for 3 swings - get at least 5 values
b) use the longest length, change the height you drop it

from

Observations:

a) changing length:

Time for 3 swings(s)	Period, T(s) (time/3)	Length(m)	root length $\sqrt{L}$ ($\sqrt{m}$)

Time for 3 swings(s)	Period, T(s)	drop height H(m)

b)

Analysis - graph T vs $\sqrt{L}$
graph T vs H

conclusion
sources of uncertainty

Due Tuesday, Oct 6

Friday, October 02, 2015
8:40 AM

Block 2-1
go over quiz, lab - %error, review kinematics
Q1
182.3 cm (1m/100cm) = 1.823m
1000mm = 1m
10^9nm=1m
1nm=10^{-9}m
Q2
0.0000001 has 1 sf
Q3
round answer to the least number of sig figs
eg. 14.25m x 4.7m = 14.25x4.7=66.975
67m^2

4
b) 9.90km + 3.10 x 10^2m

$$
\begin{array}{r l}
9.90 & km \\
+\ 0.310 & km \\
\hline
10.210 &
\end{array}
$$

10.21 km

$$\rho = \frac{m}{V} = \frac{67.93\,g}{5.18\,cm \times 1.21\,cm \times 1.205\,cm}$$

$$= \_\_\_\_\_$$

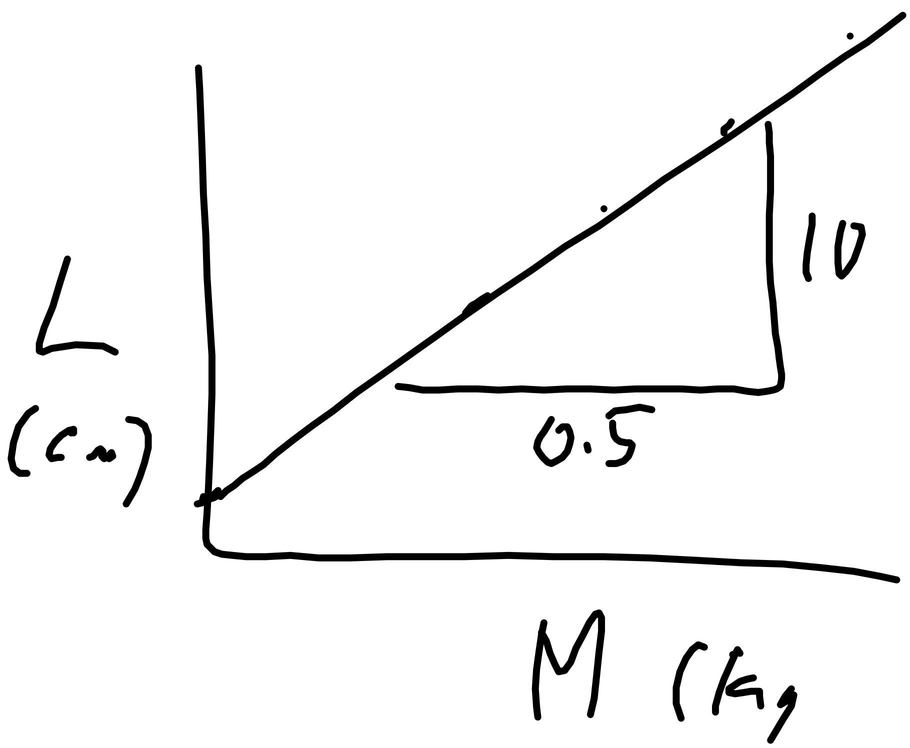
67.93/(5.18x1.21x1.205)=8.9941

8.99 g/cm^3

b) %error = (8.9941-7.86)/7.86=0.1443

14.4%

(7.98-7.86)/7.86=0.0153 = 1.5%

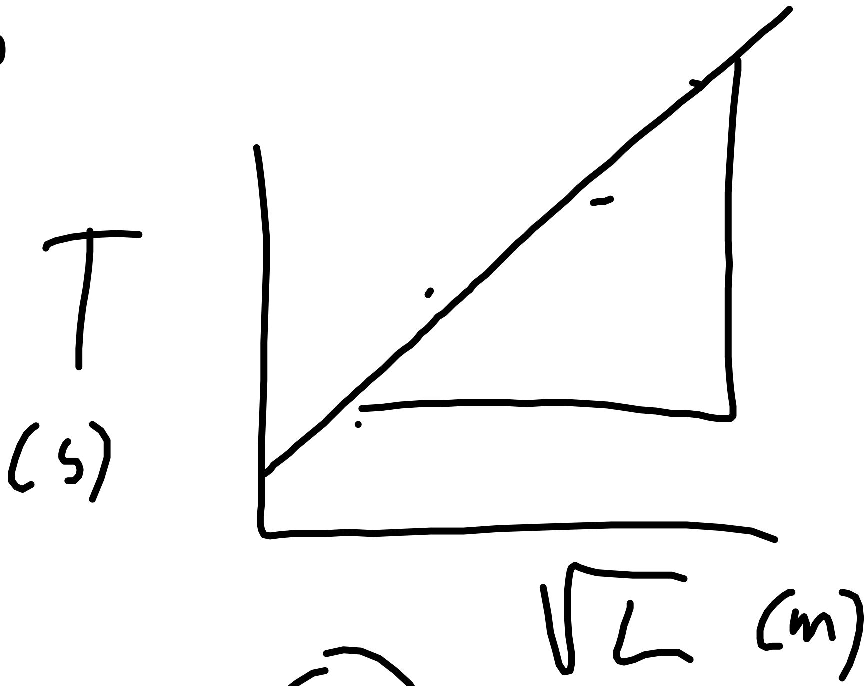


Slope = 20 $\frac{cm}{kg}$

$y = mx + b$

$L = 20\,\frac{cm}{kg} M + 20$ (cm)

Lab



$2.5 \frac{s}{\sqrt{m}}$

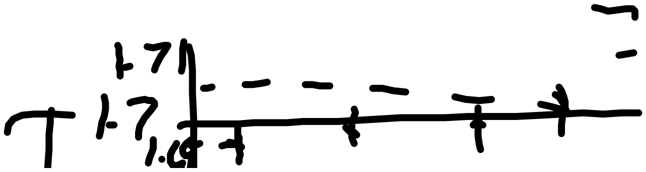
$$T = \frac{2\pi}{\sqrt{g}}\sqrt{L}$$

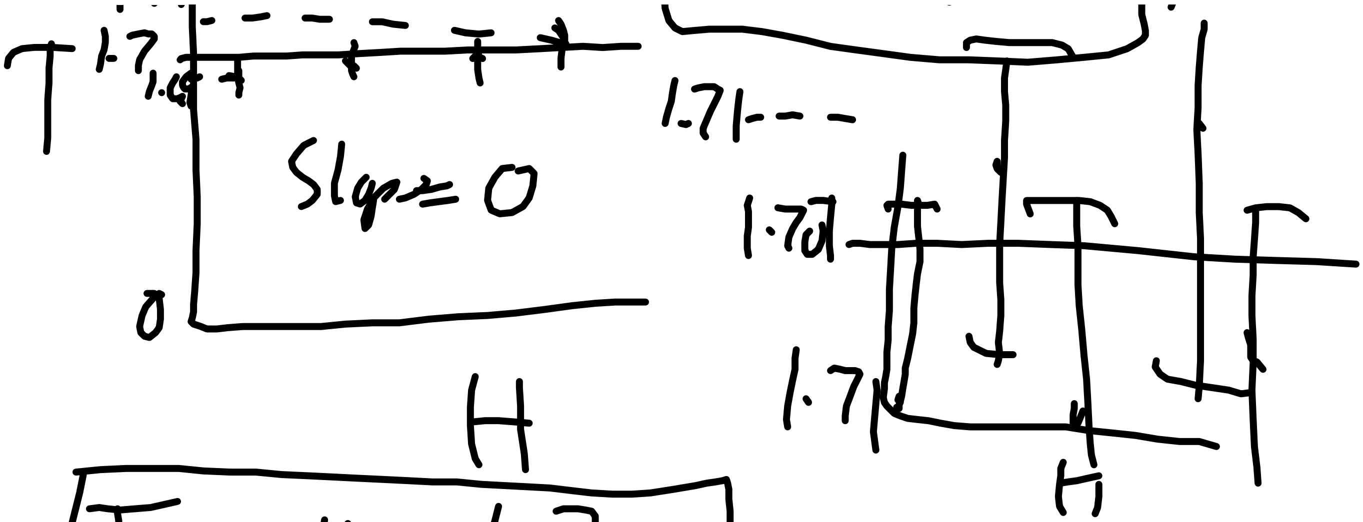
= slope of T vs √L graph

$$\frac{2\pi}{\sqrt{9.80\ m/s^2}} = 2.007 \frac{s}{\sqrt{m}} = \text{theo.}$$

$$\%\ \text{error} = \frac{\left|2.5 \frac{s}{\sqrt{m}} - 2.007 \frac{s}{\sqrt{m}}\right|}{2.007 \frac{s}{\sqrt{m}}} \times 100$$

= 25% error





$T = 0H + 1.7s$

Kinematics - Velocity (Chapter 3)

Defining terms:
vector: quantity with magnitude and direction
scalar: quantity with magnitude only
Distance: How far apart are two points?
symbol: d units: m   scalar

Position: where something is relative to a reference point.
symbol: x,y or z units: m and direction in degrees vector

Displacement: change in position (final

position - initial position) vector subtraction
symbol-d (s) units are m and degrees

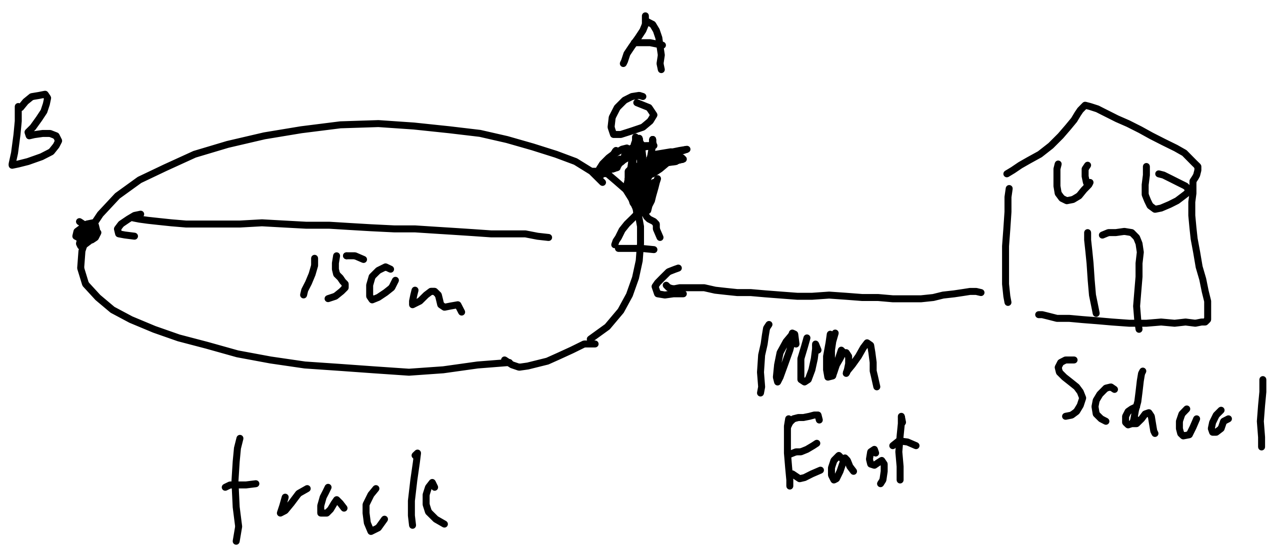
Speed: rate of covering distance
symbol-v
units: m/s scalar

Velocity - rate of change in position
symbol v
$v = \Delta x/\Delta t = d/t$ if the velocity is constant

if the velocity is not constant, then:
Average velocity, $v_{avg} = d/t$

Instantaneous velocity = velocity at a certain point.

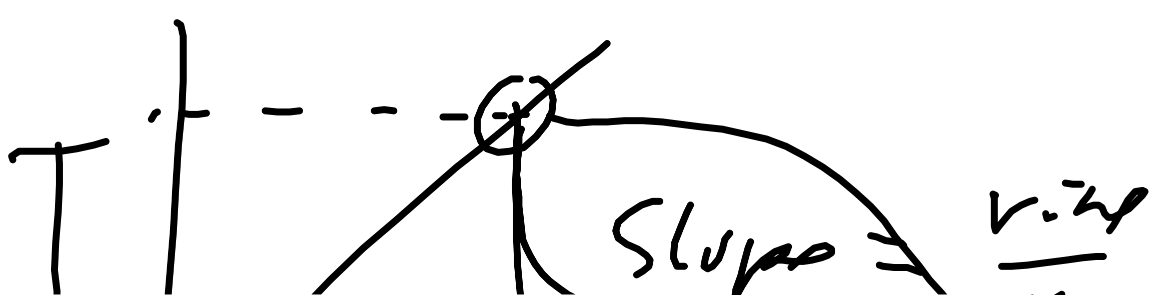
eg. You run 6 laps of the 400m track, that is 100m East of the school.

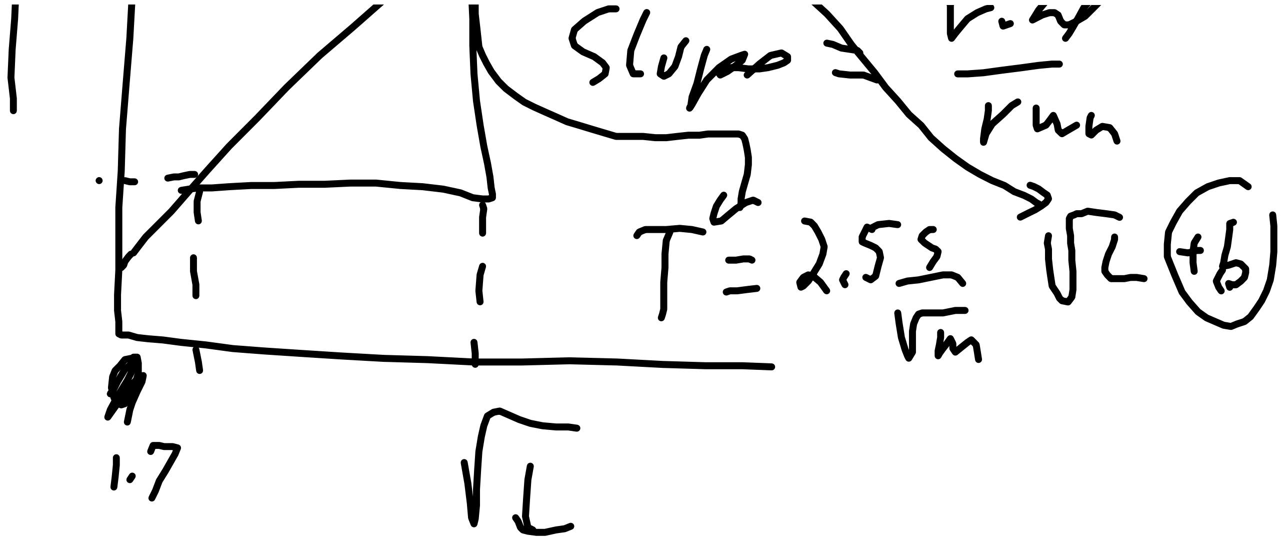


if you take 6.0 minutes to do the first 3 laps and 4.0 minutes to do the next 2 laps and 1.0 minute for the last lap. determine:

a) initial position relative to the school
b) distance travelled
c) displacement at B
d) your total displacement
e) your average speed overall
f) your average velocity overall
g) your average speed for each section
h) your instantaneous velocity at B of the final lap

a) 100m East
b) 6x400=2,400 m
c) 150m East
d) 0 (you end up at the same point)
e) 2400/(6+4+1)=218.1818
218 m/minute = 218/60=3.63 m/s
f) 0
g) 3x400/(6x60)=3.33m/s
2x400/(4x60)=3.33m/s
1x400/(60)=6.67m/s
h) 6.67m/s North





Block 2-2
Quiz, Lab %error, Kinematics

Quiz
1
a) 182.3cm (1m/100cm)
1.823m
1000mm = 1m
10^9nm = 1m
2
0.0000032 is 2 sfs

3 round answer to lowest number of sf
14.25x4.7=66.975 = 67m^2
19.99 = 20. 2.0 x 10^1 m^2

4. round answer to least precise decimal

4. round answer to least precise decimal

9.90 km
+ 0.310 km
11.210

= 11.21 km

a) 5 density = m/V = 67.93/(5.28x1.210x1.205)=8.8238

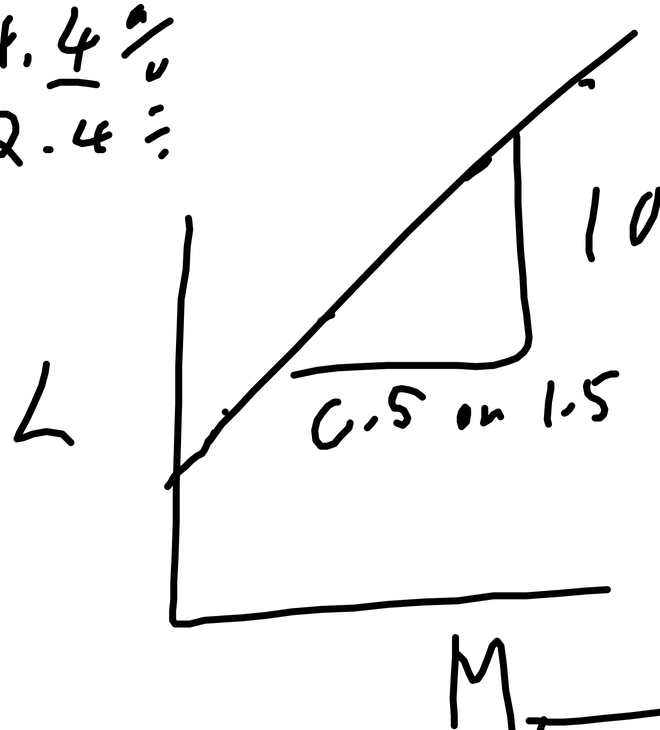
8.82 g/cm^3

b) %error = (8.8238-7.86)=0.9638 /7.86=0.1226

12%

14.4%

22.4%



10 m/kg

20 m/kg

6.7 m/cps

L = 20 m/kg M + 20 cm

$L = 20\,\frac{m}{kg}\,M + 20\,cm$

$2.5\,\frac{s}{\sqrt{m}}$

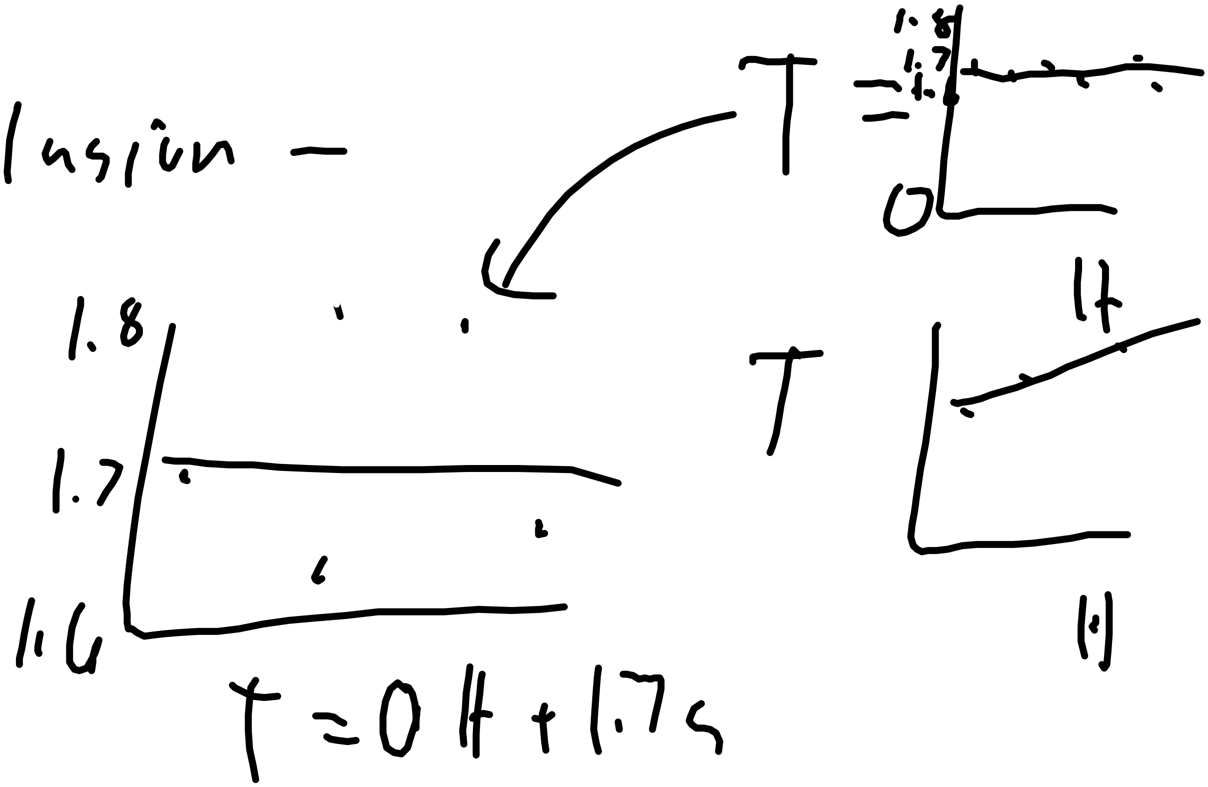
$T = \frac{2\pi}{\sqrt{g}}\sqrt{L}$

T vs √L ← slope

$2 \times 3.14159 / \sqrt{9.80\,\frac{m}{s^2}} = 2.00\,\frac{s}{\sqrt{m}}$

$\%\,error = \frac{(slope - 2.00)}{\quad} \times 100\%$

Conclusion –



Kinematics-velocity Chapter 3

Review - Write each term and the definition, symbol, and unit you remember from grade 10. leave a space for corrections.

Vector - quantity with magnitude and direction
scalar- quantity with magnitude but no direction
distance: amount of space between two points.
symbol: d units: m scalar

position: where you are relative to a reference point and direction.
symbol: x,y or z units: m and degrees vector

displacement: change in position, (final-initial)
symbol: d units: m and degrees vector

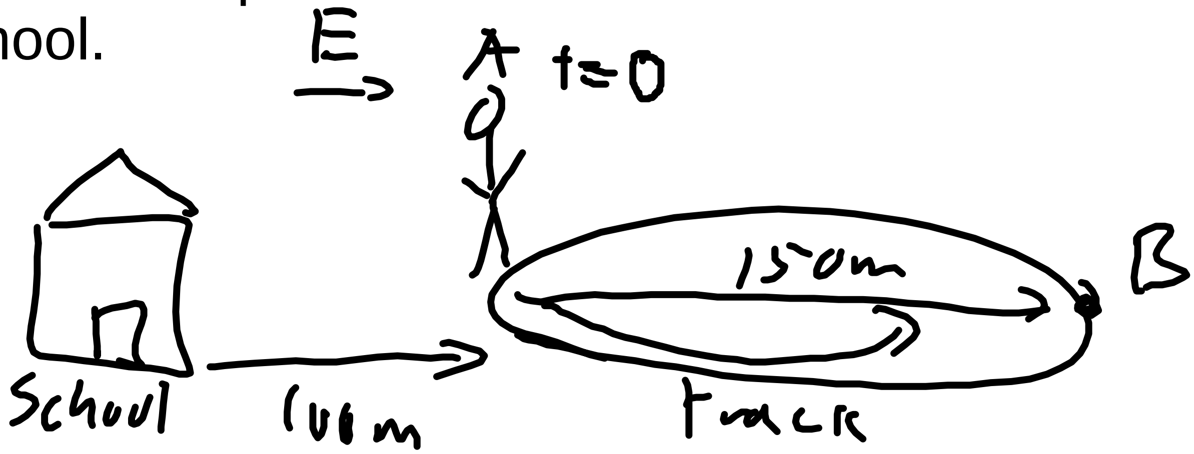
speed: rate of distance travelled
symbol: $v=d/t$ for constant speed
units: m/s scalar

velocity: rate of change in position
$v=\Delta x/\Delta t$
$v=d/t$ for constant velocity motion
units: m/s vector

average velocity: total displacement / total time
$v_{avg} = d/t$

instantaneous velocity - velocity at a certain point

You run 6 laps of a 400m track 100m East of the school.



if you take 6.0 minutes to do the first 3 laps and 3.0 minutes to do the next 2 laps and 1.0 minute for the last lap. determine:

a) initial position relative to the school

100m East

b) distance travelled
6x400=2,400 m

c) displacement at B
from A to B you are displaced 150m East

d) your total displacement
0, you end up where you began

e) your average speed overall
v_{avg}=d/t = 2400/(10x60)=4.0m/s

f) your average velocity overall
0 displacement=0

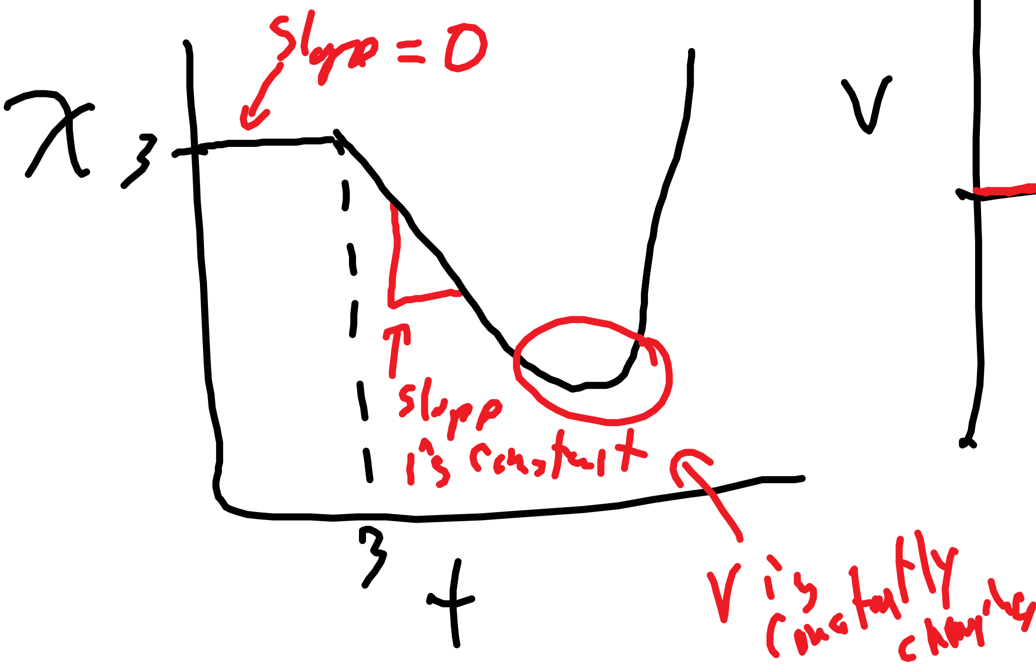
g) your average speed for each section
first 3 laps 3x400/(6x60)=3.3m/s
next 2 laps 2x400/(3x60)=4.4m/s
last lap 400/(60)=6.7m/s

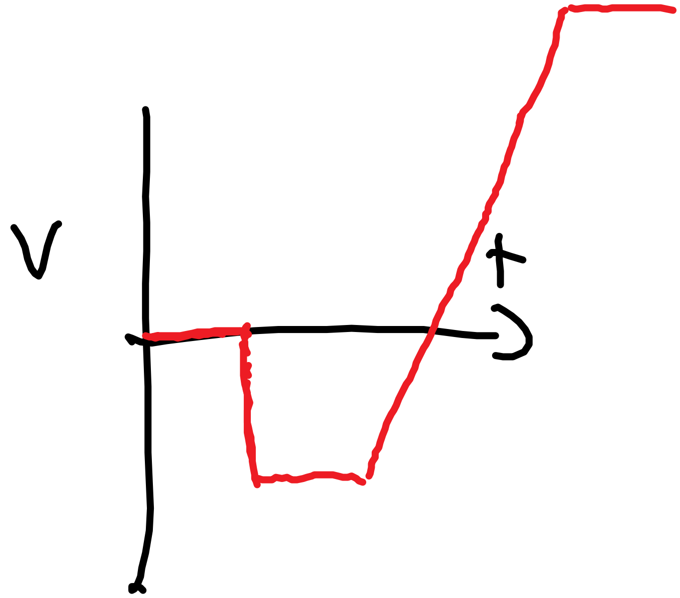
h) your instantaneous velocity at B of the final lap
assuming constant speed for the lap,
= 6.7m/s North

Block 2-1 Short class

position-time graphs and velocity

Patrick's motion





Slope of a position - time graph (or a displacement - time graph) is velocity.

negative slope = moving in the negative direction

flat line = not moving, v=0

linear graph = constant velocity

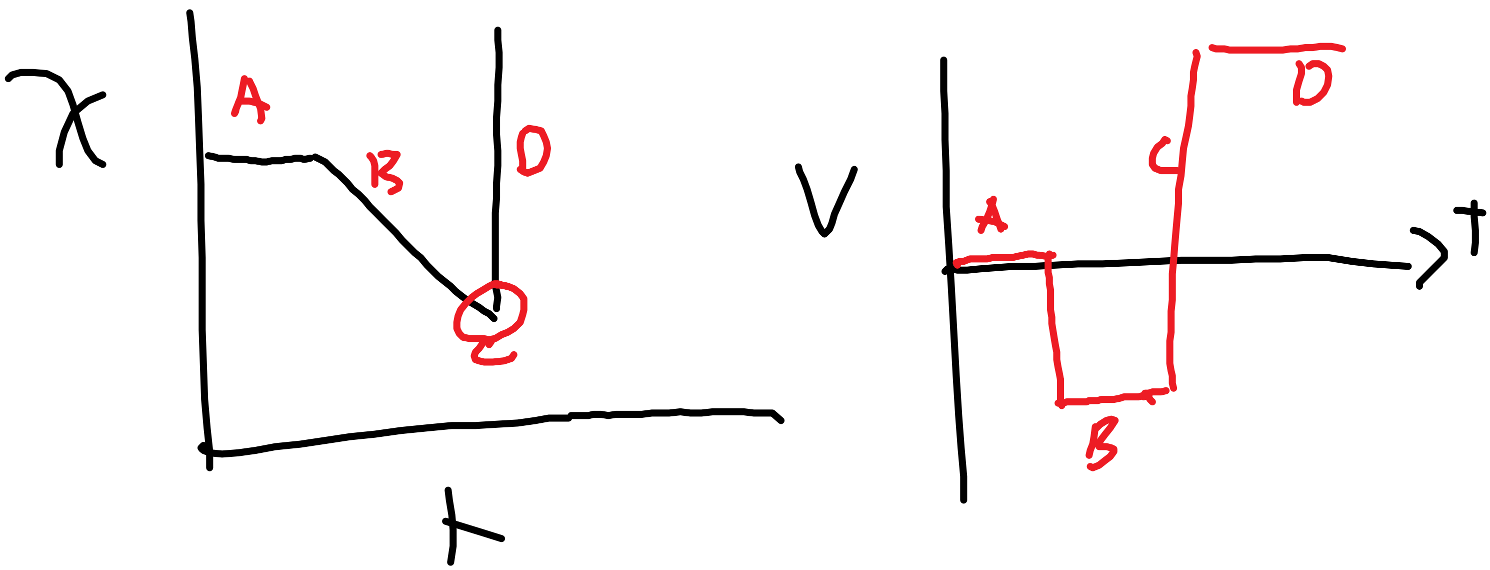
parabolic graph = constant acceleration = constantly changing velocity

p45-53 Q1-12, CR 1.1-1.4

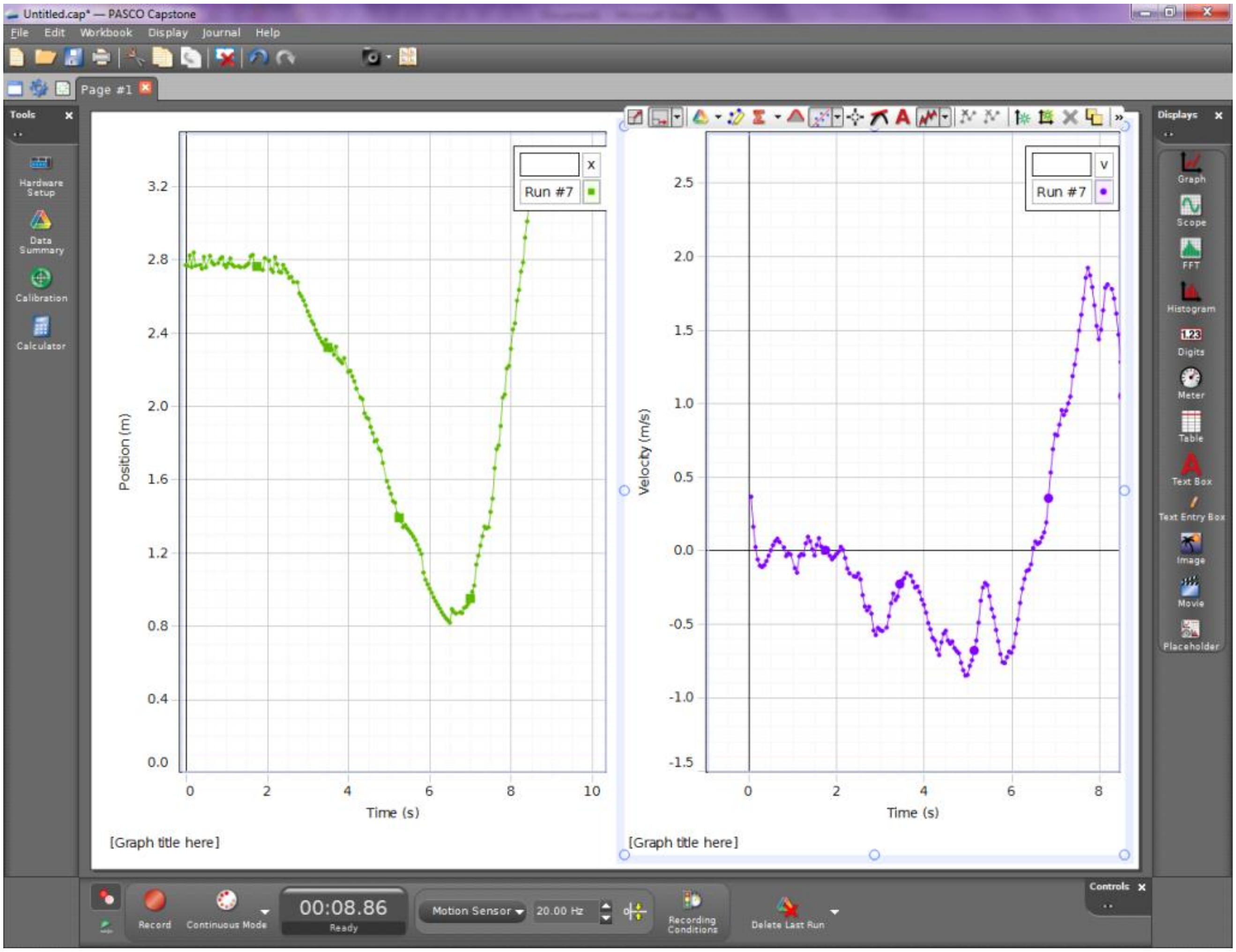
Block 2-2

Hand in Labs, Position - time graph activity

sketch Sahmi's position-time graph and describe the motion in each section
sketch a velocity -time graph of the motion



A not moving, v=0
B moving in the negative direction constant v
C parabola - constant acceleration, changing velocity
D moving fast in the positive direction
p45-53 Q1-12, CR 1.1-1.4


Untitled.cap* — PASCO Capstone
File Edit Workbook Display Journal Help
Page #1
Tools
Hardware Setup
Data Summary
Calibration
Calculator
Position (m)
Time (s)
x
Run #7
[Graph title here]
Velocity (m/s)
Time (s)
v
Run #7
[Graph title here]
Displays
Graph
Scope
FFT
Histogram
Digits
Meter
Table
Text Box
Text Entry Box
Image
Movie
Placeholder
Record
Continuous Mode
00:08.86
Ready
Motion Sensor
20.00 Hz
Recording Conditions
Delete Last Run
Controls

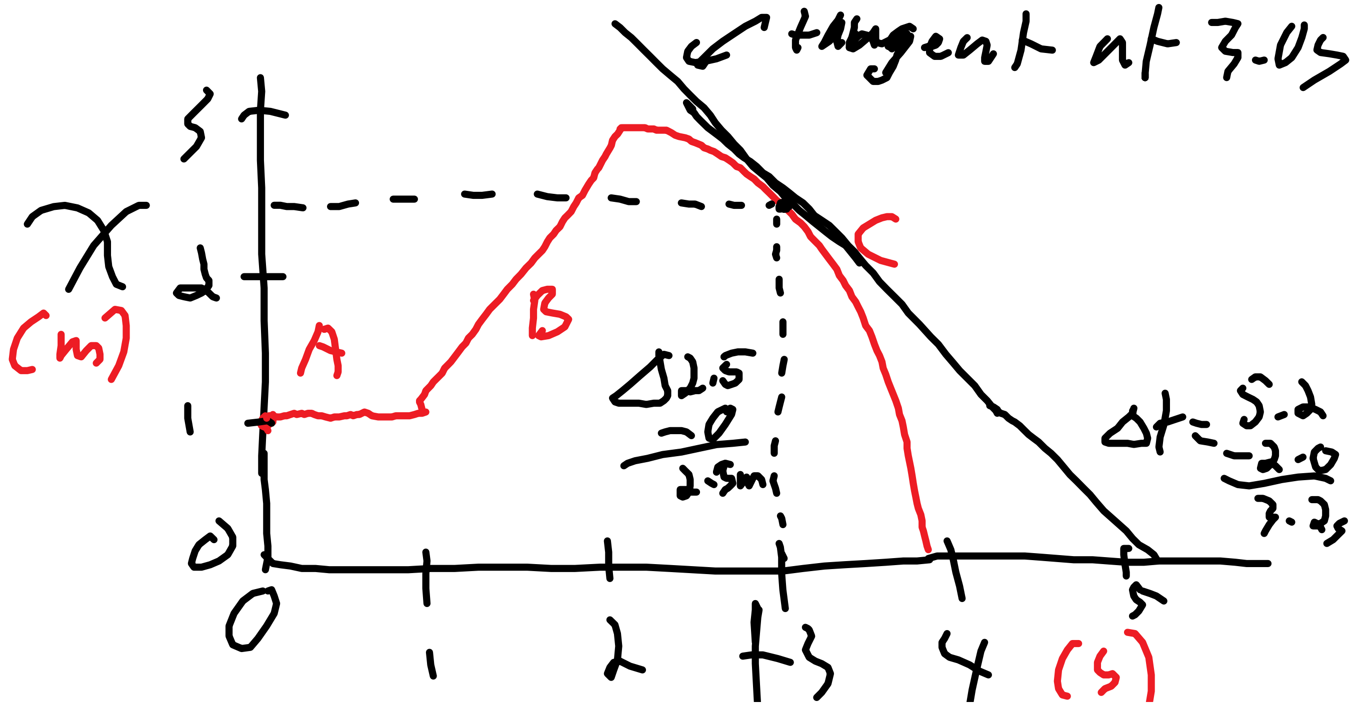
Block 2-1

Instantaneous velocity

The velocity at a specific time.
If you are moving at a constant velocity, your instantaneous velocity and average velocity are the same. But if you velocity is changing (acceleration) the average velocity v_{avg} = total displacement/total time
$v_{avg}=d/t$
but the instantaneous velocity is the rate of change in position at that time: slope of the graph at that time.

what if the d-t graph is a non-linear curve?
- draw a tangent to the curve at the point in time
- a line that touches the curve at that point and goes in the direction of the curve.
- Math keeners can also use calculus - derivative.

eg.



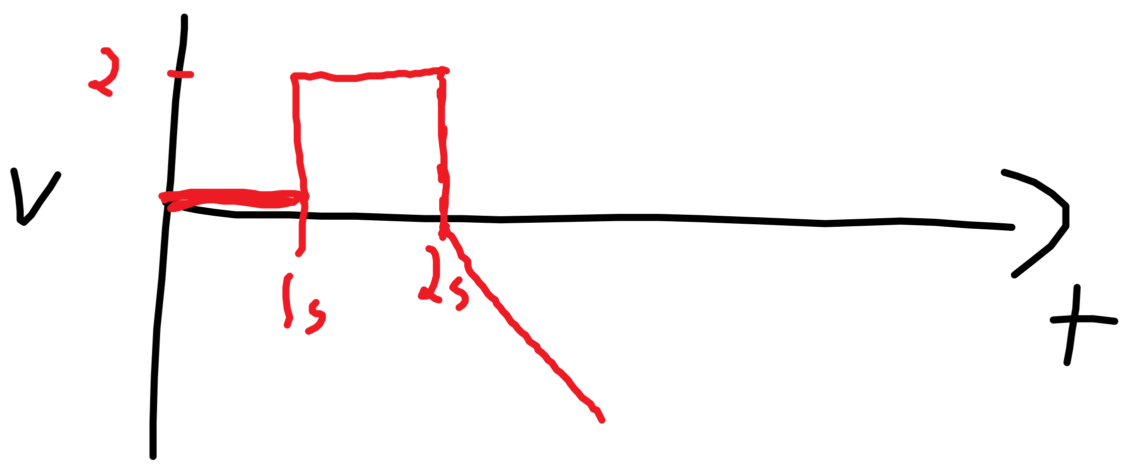
1. describe the motion in each section
2. calculate the velocity at A, B and at 3s.
3. graph a v-t graph for the data

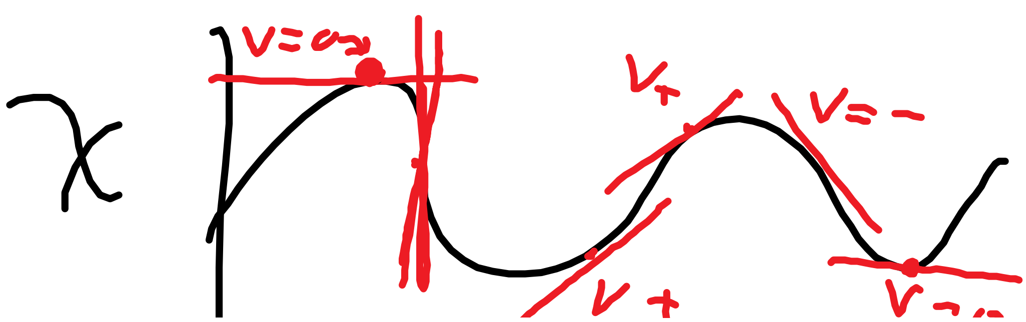
1.
A is standing 1.0 m away from the reference point for 1.0 s.
B is moving in the positive direction at a constant speed.
C speed up in the negative direction

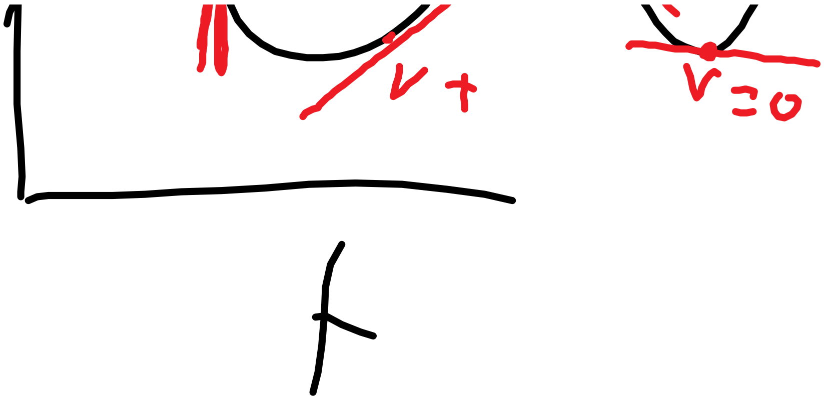
2. A v=0
B v=d/t = (3m-1m)/1s= 2.0m/s
at 3.0 s,

~~2.5m − 0m~~ 0−2.5

$$V = \frac{0 - 2.5}{5.2s - 3s} = -1.1 m/s$$







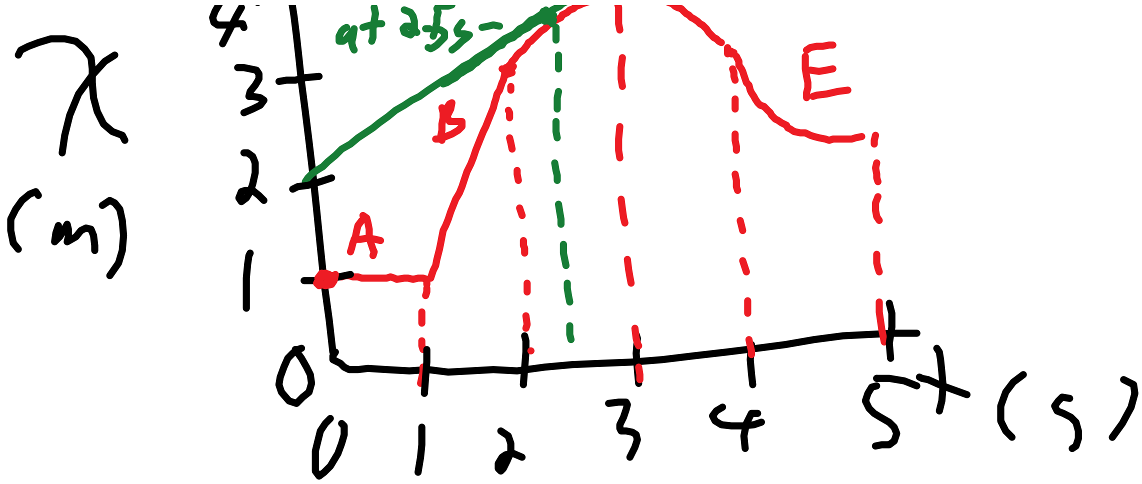
Block 2-2
Instantaneous velocity

The velocity at a certain time.
If the velocity is constant, then the instantaneous velocity, v_{inst}, and the average velocity, v_{avg}, are the same.

If the velocity changes, the v_{avg} is the total displacement/total time $v_{avg}=d/t$
but the instantaneous velocity is the slope of the graph at each point. If the graph is a curve, then find the tangent line to the curve at that point and determine the slope.

- the tangent is a line touching the curve at one point and in the general direction of the curve.

eg. A graph of the motion of a student walking.

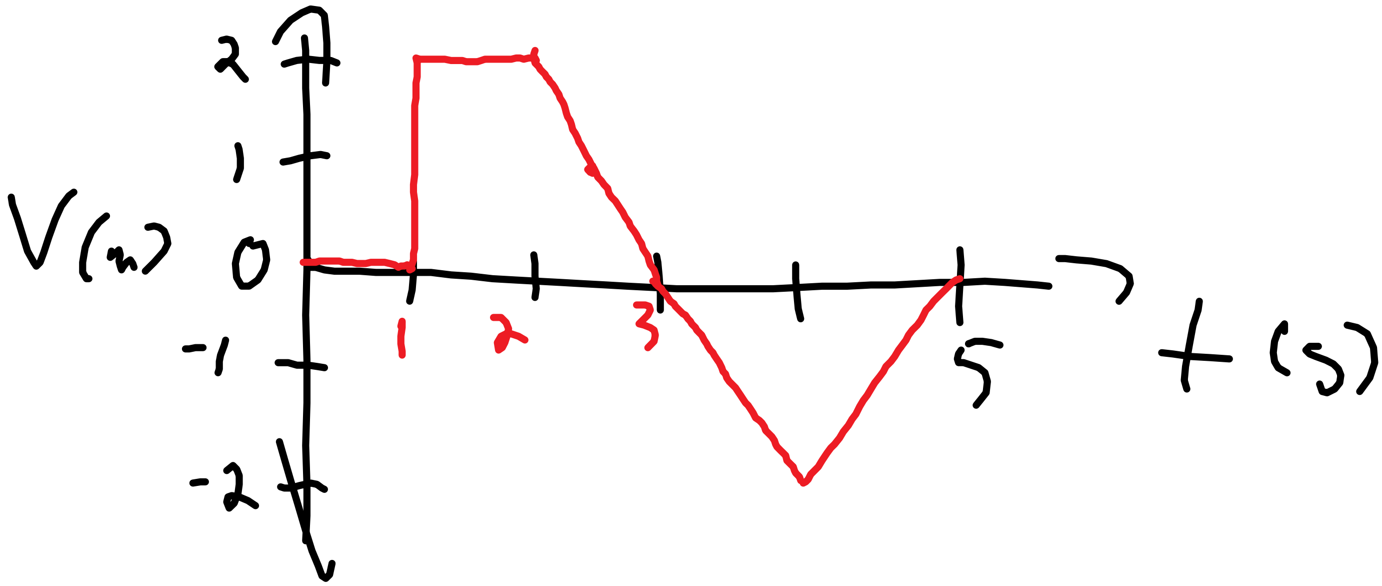


Assume the curves are parabolas

1. describe the motion in each section
2. calculate the instantaneous velocity at the middle of each section and at 3.0s
3. draw a velocity -time graph of the motion

1. A not moving at 1.0m
   B moving at a constant velocity in the positive direction
   C slowing down in positive direction
   D speed up in negative direction
   E slowing down in negative direction

2. A v=0
   B $v = \Delta x/\Delta t$ = (3m-1m)/1s = 2.0m/s
   C v= (3.5m-2.0m)/(2.5s-0)= 1.5/2.5=0.60m/s
   D -0.60m/s
   E -0.60m/s
   at 3.0s v= 0

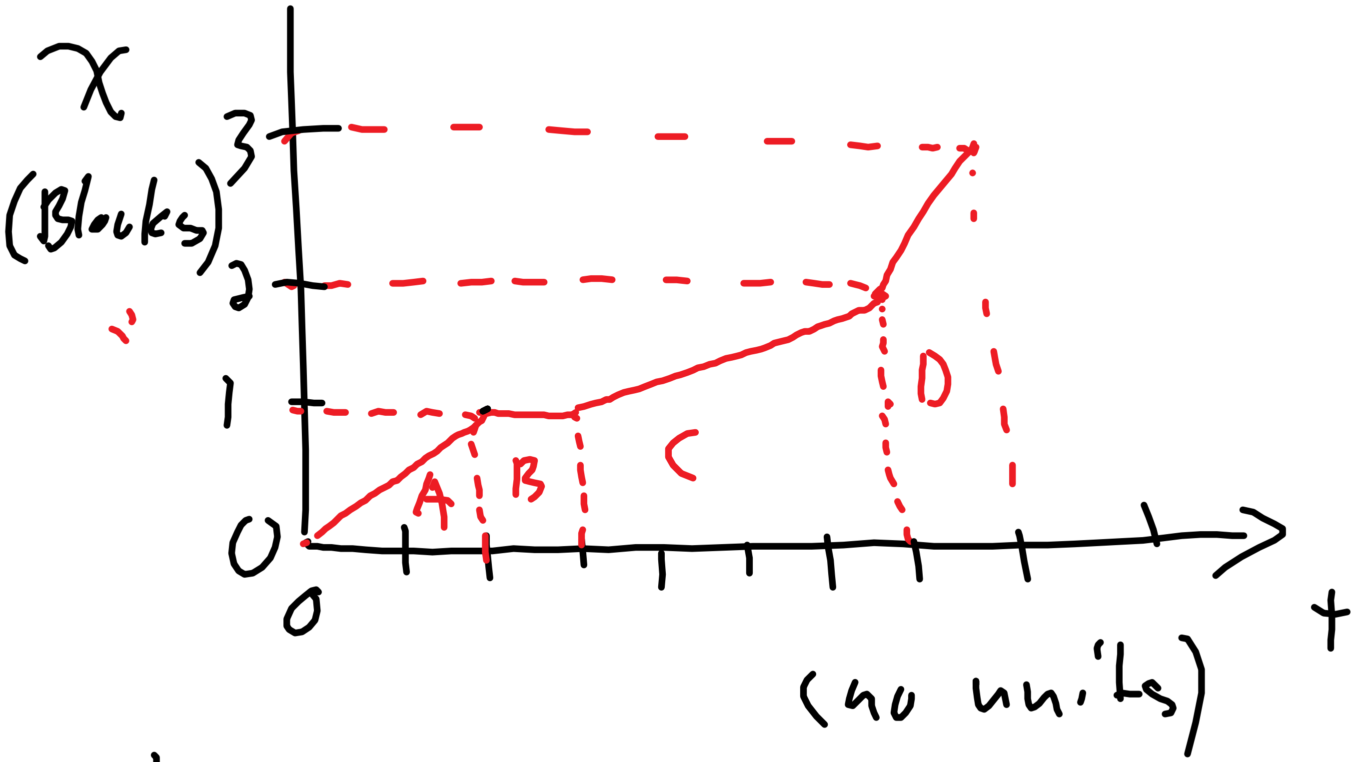

V (m)
2
1
0
-1
-2
1
2
3
5
t (s)

Block 2-1
Acceleration
but first: Homework
p49 CR 1.1
the period on the page is:
book: p49 14.3cm from the bottom of the page and 4.5 cm from the binding
table: ____cm from the North edge and ___cm from the East edge
room: 1.5m North of Mr. K.

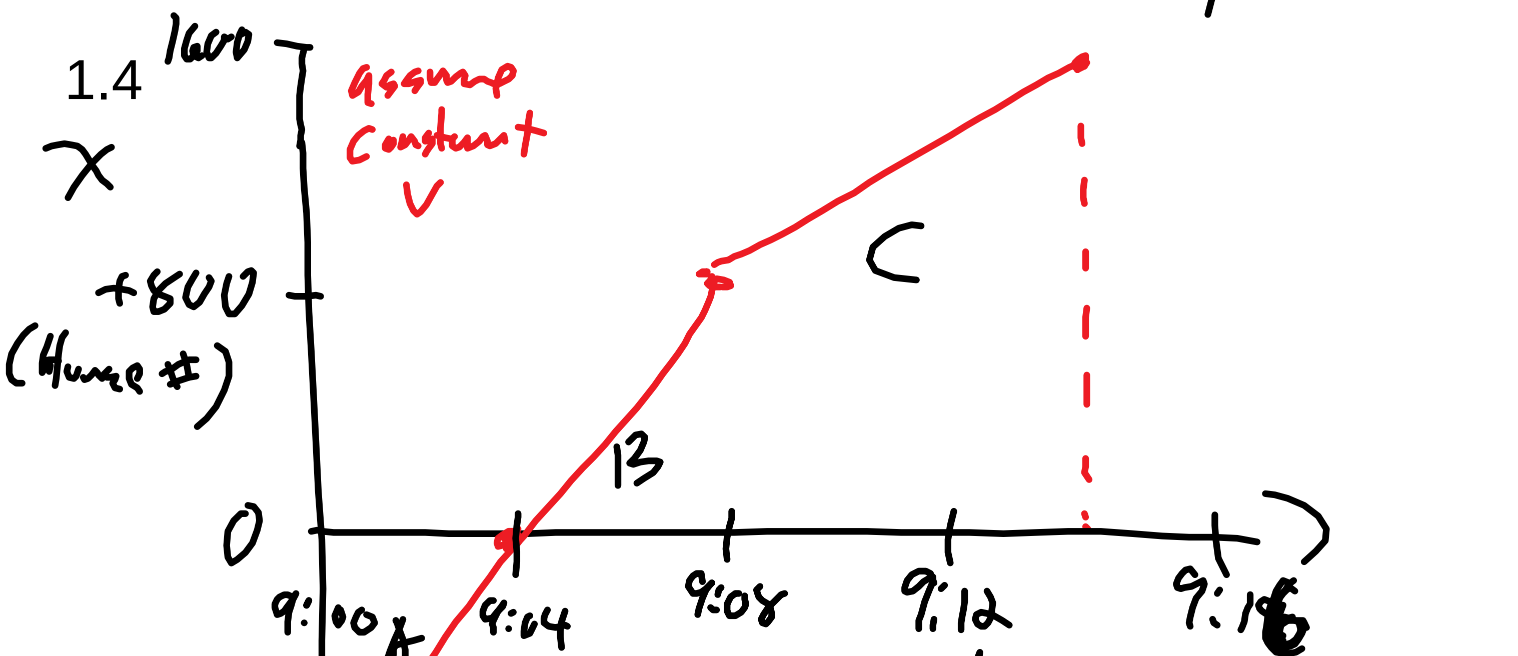
1.2 A) hand starts above the desk and doesn't move

B) starts at the origin(desk) and moves away at a constant speed
C) starts above the desk and moves at the same speed as B (same slope)
D) starts at origin(desk) moves away slowly (low slope)

1.3



1.4



$$V_{avg} = \frac{d_{total}}{t_{total}} = \frac{x_f - x_i}{t}$$

$$V_{avg} = \frac{1600 - (-800)\#}{14\,min} = \frac{2400}{14} = 171.43\ \#/min$$

1.7×10^2 #/min

A and B $V = \frac{800}{4\,min} = 200$ #/m

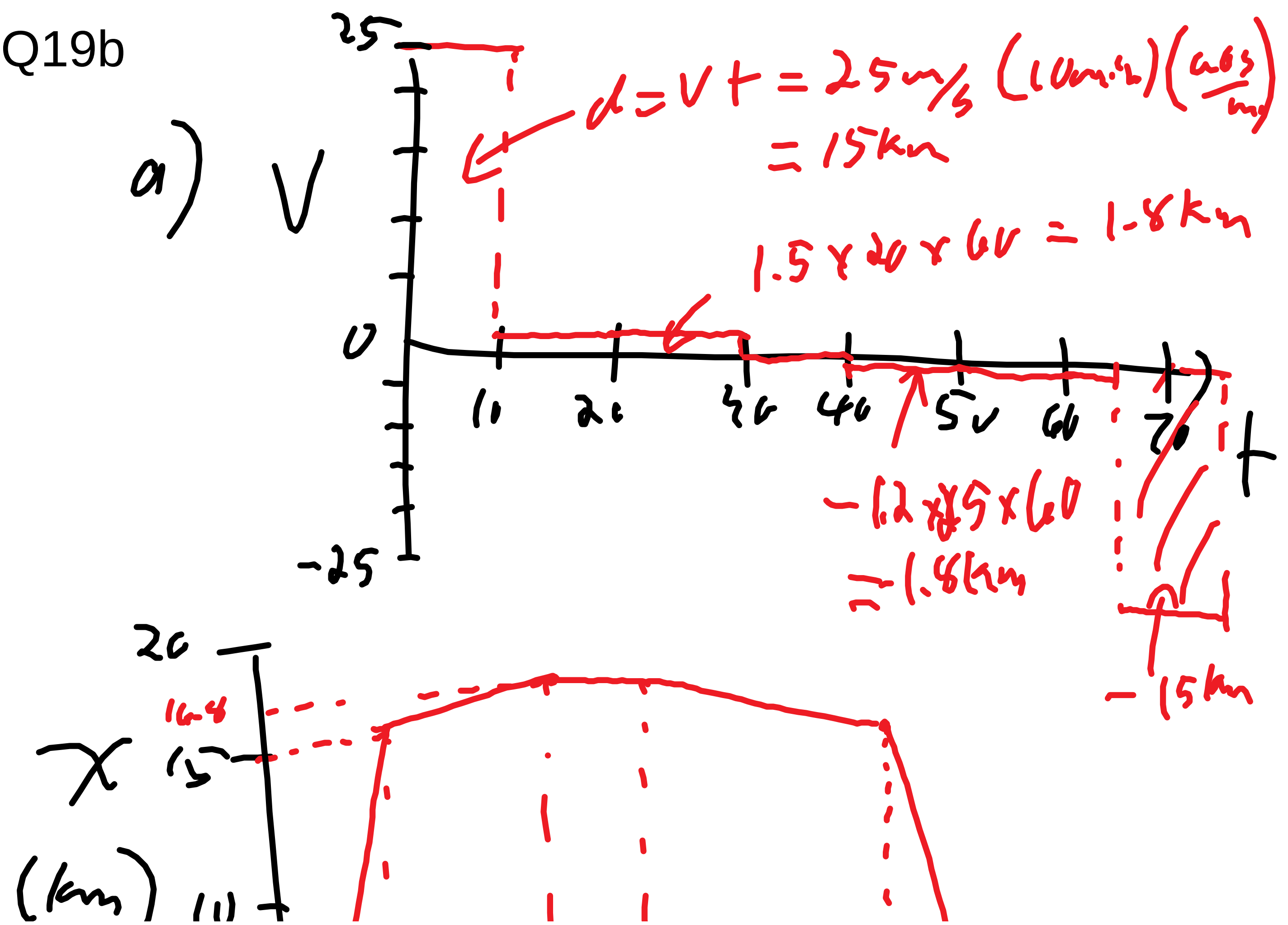
2×10^2 #/m

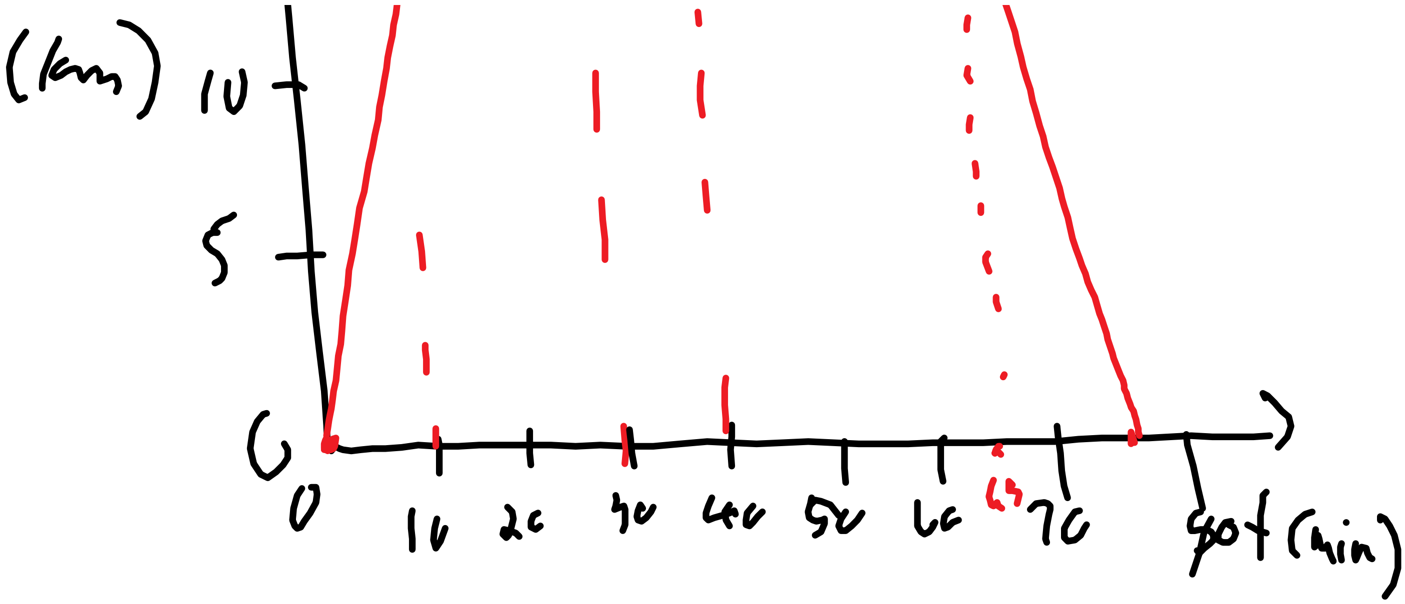
C $V_{avg} = \frac{800}{6\,min} = 133$ #/min

1×10^2 #/min

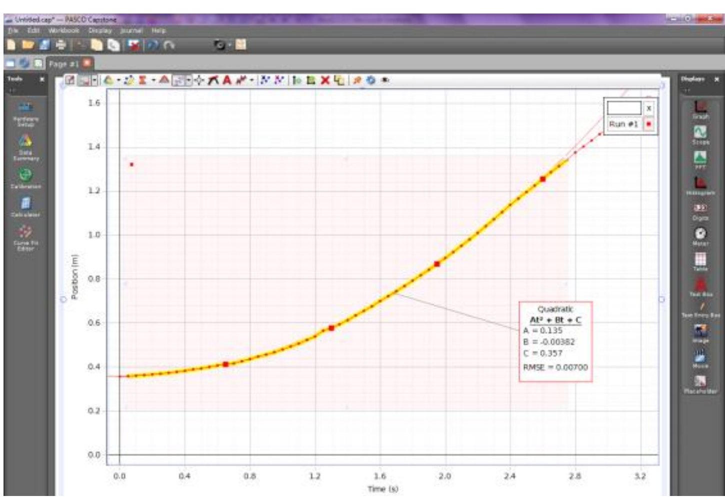
Q19b

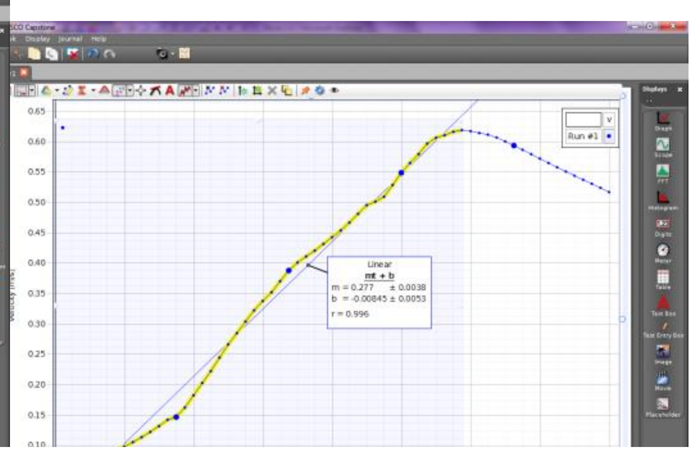
a)

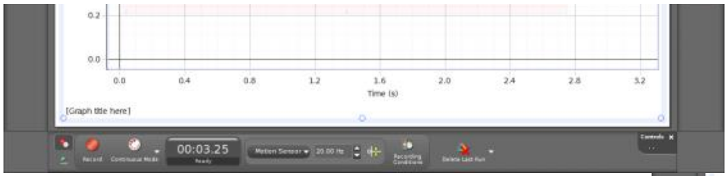


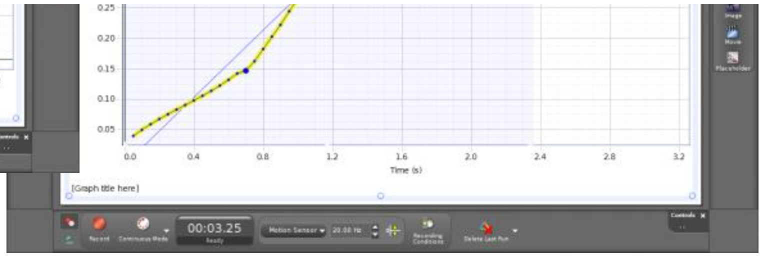


motion of a cart rolling down a slope (lab Friday)









position - time graph is a parabola

velocity-time graph is linear (ish)
slope is acceleration

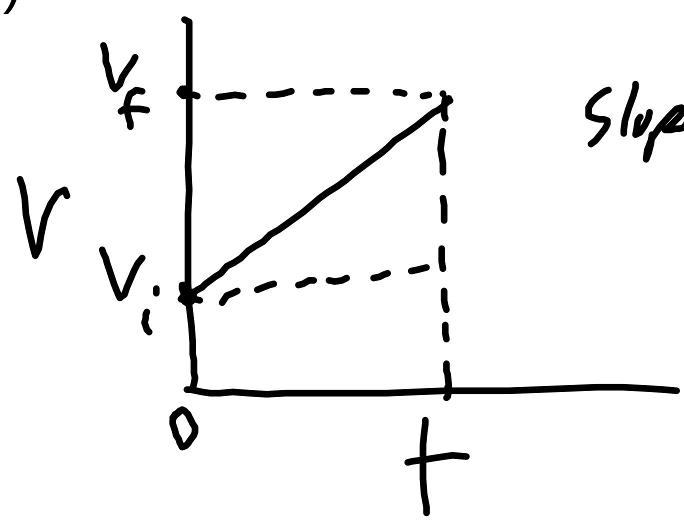
Chapter 4 in textbook

Acceleration is defined as the rate of change of the velocity with respect to time.
(recall, velocity is the rate of change in position vs time)

$v=\Delta x/\Delta t$ the slope of a x-t graph (or d-t)

$a=\Delta v/\Delta t$ the slope of a v-t graph

if the acceleration is constant, the v-t graph is linear
(the example graph is linear until the cart goes off the ramp)



$$\text{slope} = a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t}$$

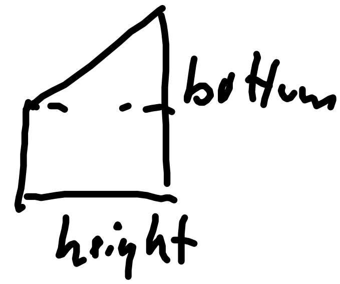
$$a = \frac{v_f - v_i}{t}$$

or $\boxed{v_f = at + v_i}$

v_i is the initial velocity, at t=0
v_f is the velocity at t=t

remember from the homework, area under a v-t graph gives us the displacement, d.
area under the v-t graph is a trapezoid

$$\frac{(top + bottom)}{2} \times height$$



$$area = d = \frac{(v_i + v_f)}{2} t = d = \frac{1}{2}(v_i + v_f)t$$

eg. You ride a bicycle at 5.0m/s and accelerate to 9.0m/s over 2.0s. Determine
a) acceleration b) displacement in that time

a) v_i=5.0m/s v_f=9.0m/s t=2.0s a=?
$v_f = at + v_i$ a= (v_f-v_i)/t = (9.0m/s-5.0m/s)/2.0s =
2.0m/s²

b) v_i=5.0m/s v_f=9.0m/s t=2.0s d=?
d = 1/2 (v_i+vf)t = 1/2(5.0m/s + 9.0m/s)2.0s
=14 m

HW study for quiz: P58-59 AC (applying concepts) 1,2, 7, 8, 9, 10 ,11 P61 Problem 21,24

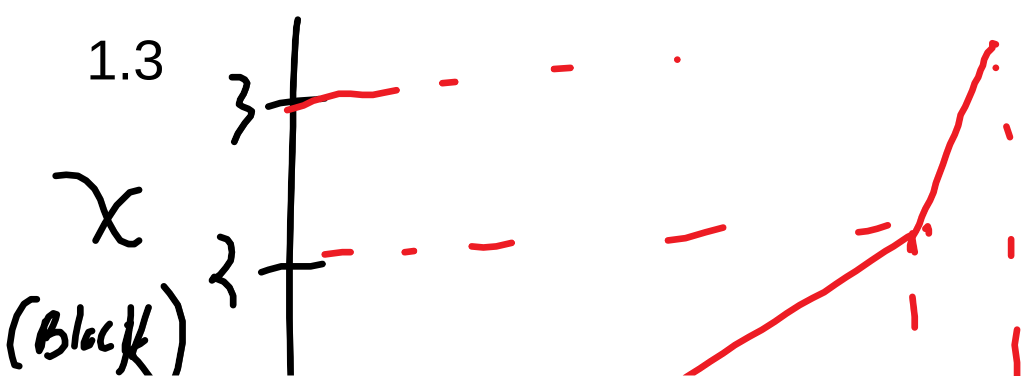
p66 PP 1-4

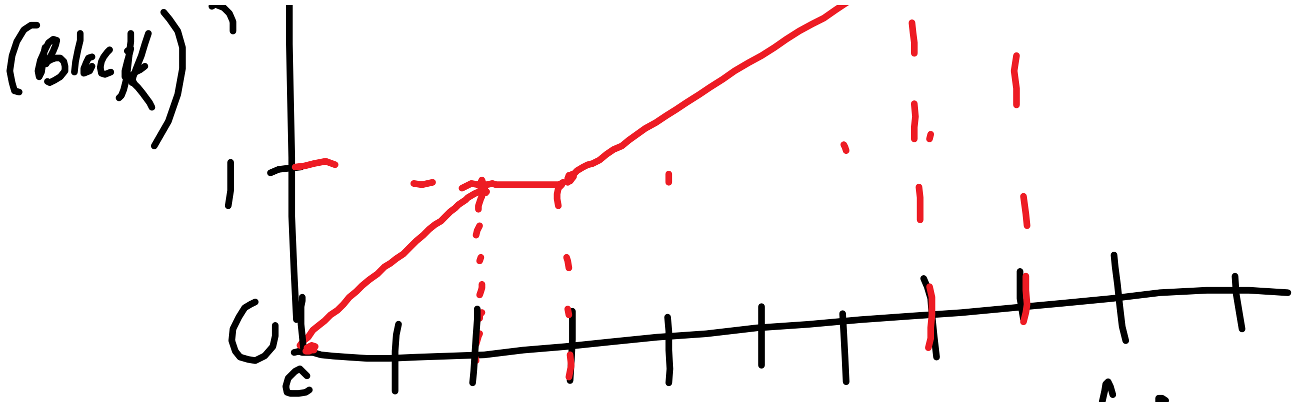
Block 2-2
Homework and acceleration intro

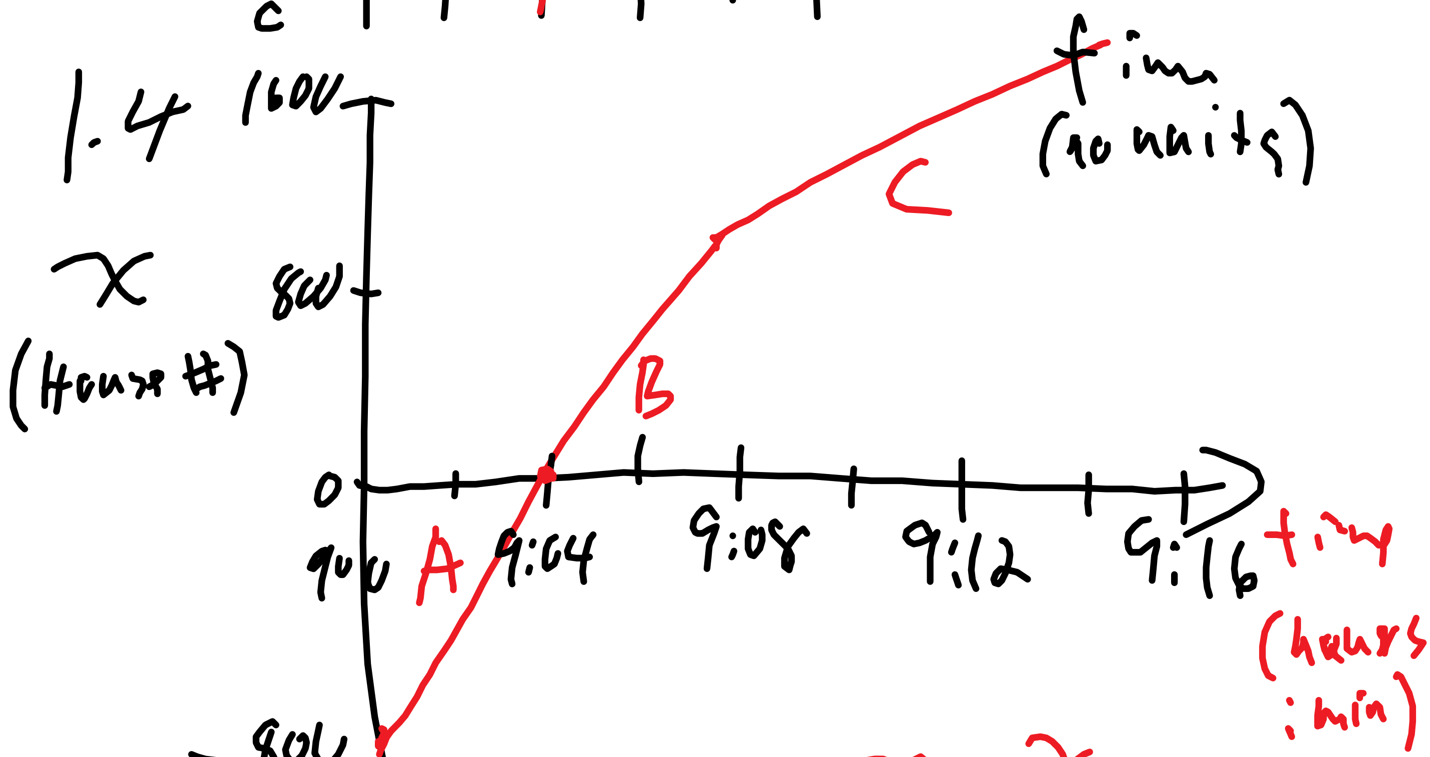
p49
CR 1.1
the period can be found
book: p49 12.3 cm from the bottom of the page and 4.5 cm from the left side.
table: ___cm North of the South edge, ____cm East of the West edge.
room: 2.5 m 30.0º East of North from Mr.K.
1.2 set the table as position 0.

A) Hand starts above the table and doesn't move
B) Hand starts at the table and moves away at constant speed
C) Hand starts above the table and moves away at constant speed, same speed as B (same slope)
D) Hand starts at the table and moves at a constant slow speed (slope is low)

1.3







$$V_{avg} = \frac{d_{total}}{t} = \frac{x_f - x_i}{t} = \frac{1600-(-800)}{14\,min}$$

$$\frac{2400}{14} = 1.7 \times 10^2 \ \#/min$$

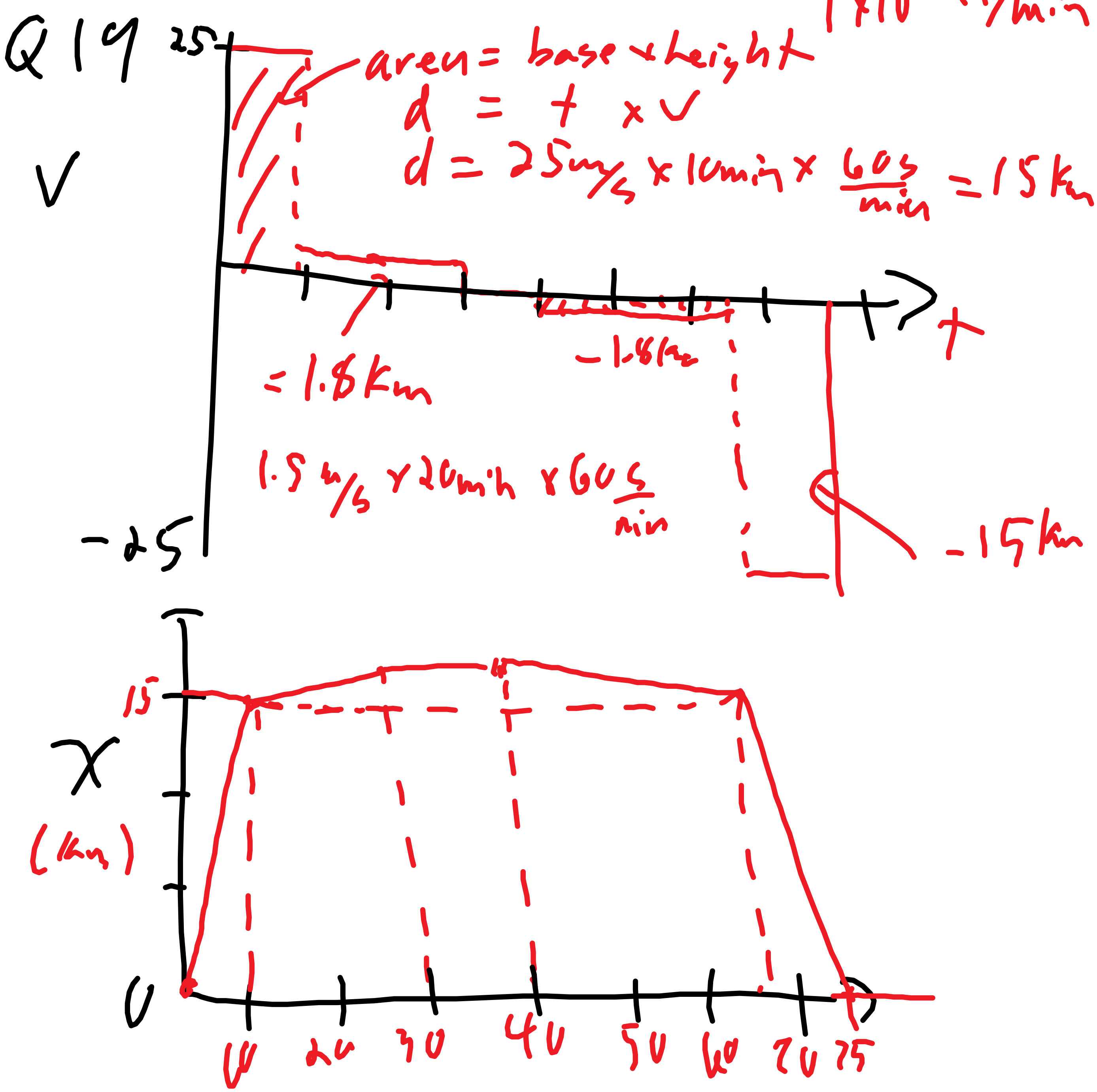
A and B $\quad V = \frac{800}{4} = 200 \ \#/min$

$2 \times 10^2 \ \#/min$

C $\quad V = \frac{800}{\ } = 133 \ \#/min$

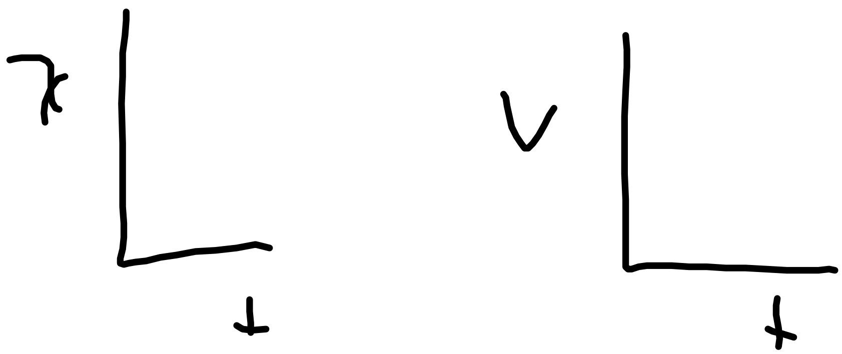
C $v = \frac{800}{6} = 133$ #/min

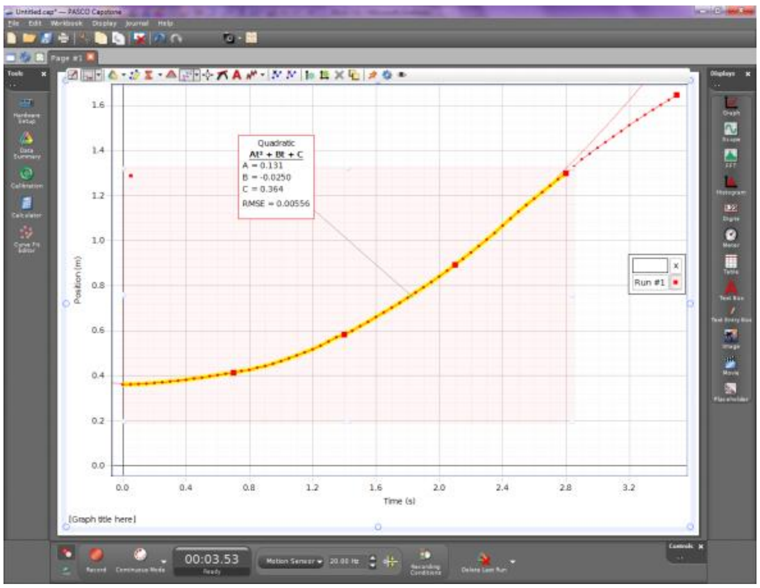
1×10^2 #/min



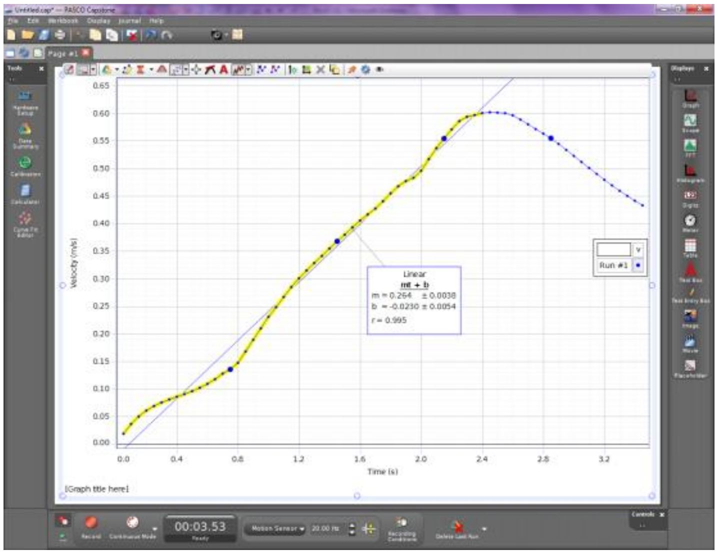
Acceleration (chapter 4 in Merrill)
Look at a cart rolling down a hill (use a motion sensor)

What should the x-t and v-t graphs look like?





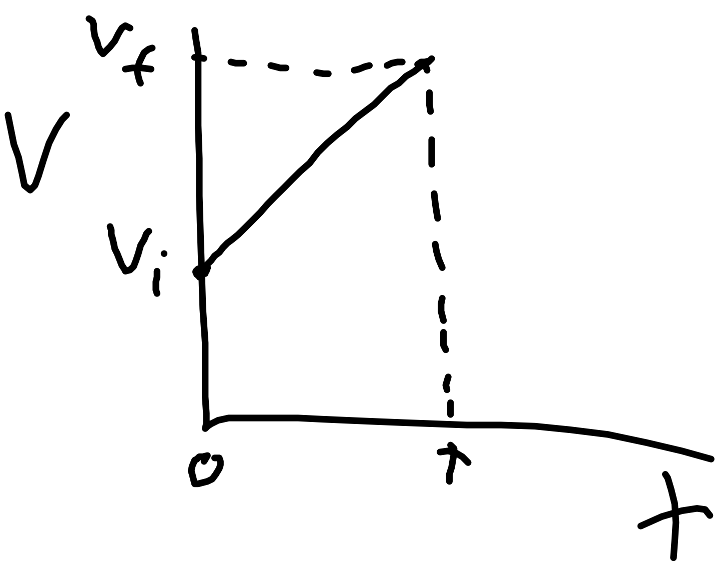
position - time graph is a parabola



velocity -time graph is linear (until the cart goes off the ramp and slows due to friction)

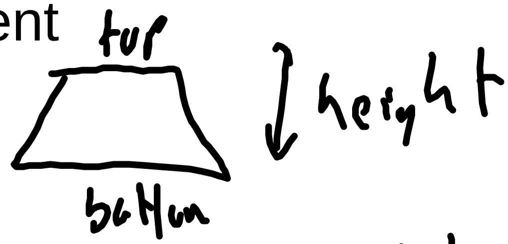
definition:
acceleration, a is the rate of change in velocity with respect to time
$a=\Delta v/\Delta t$ slope of a v-t graph
(recall $v=\Delta x/\Delta t$ the slope of a x-t or d-t graph)

if acceleration is constant (like a cart rolling down a hill) then the v-t graph is linear



v_i is the initial velocity, v at t=0
v_f is the final velocity, v at t=t
slope = a = rise/run = $(v_f-v_i)/t$
$v_f=at+v_i$ same as $a=(v_f-v_i)/t$

recall from the homework, area under a v-t graph is displacement
area of a trapezoid



$$\text{area} = \frac{\text{top} + \text{bottom}}{2} \times \text{height}$$

$$d = \frac{v_i + v_f}{2} \times t$$

$$d = \frac{1}{2}(v_i + v_f)t$$

eg. You ride your bicycle at 5.0 m/s and accelerate uniformly to 9.0m/s over 2.0s. Calculate:
a) acceleration b) displacement over the time interval
steps: 1- write out info (diagram)
2- equation
3- rearrange and sub in
4-anwer to correct sfs, units and check

a) $v_i = 5.0 m/s$ $v_f = 9.0 m/s$ $t = 2.0 s$ $a = ?$

$v_f = at + v_i$

$a = (v_f - v_i)/t = (9.0 m/s - 5.0 m/s)/2.0 s = 2.0 m/s^2$

a) $d = 1/2\ (v_f + v_i)\ t = 1/2\ (9+5)\ (2) = 14 m$

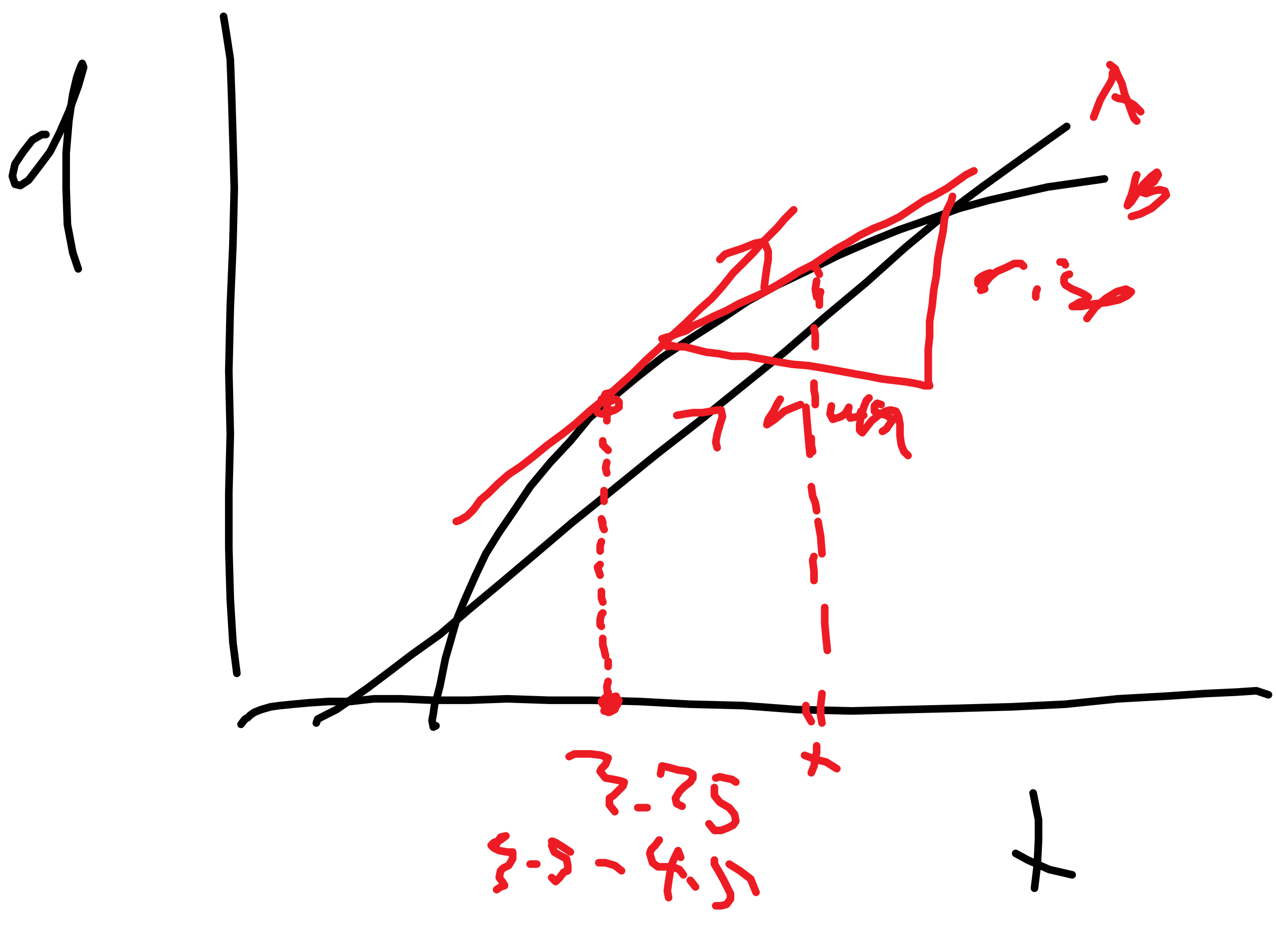
Thursday, October 15, 2015
8:45 AM

Block 2-1
go over homework, quiz, negative acceleration

P58 AC
1 - where the cars are wouldn't change but the front of the blue car would be at position -3m and the red car would be at position 6m

check website answerkey
http://physics-pages.wikispaces.com/Chapter+3

Q9



9.90 km

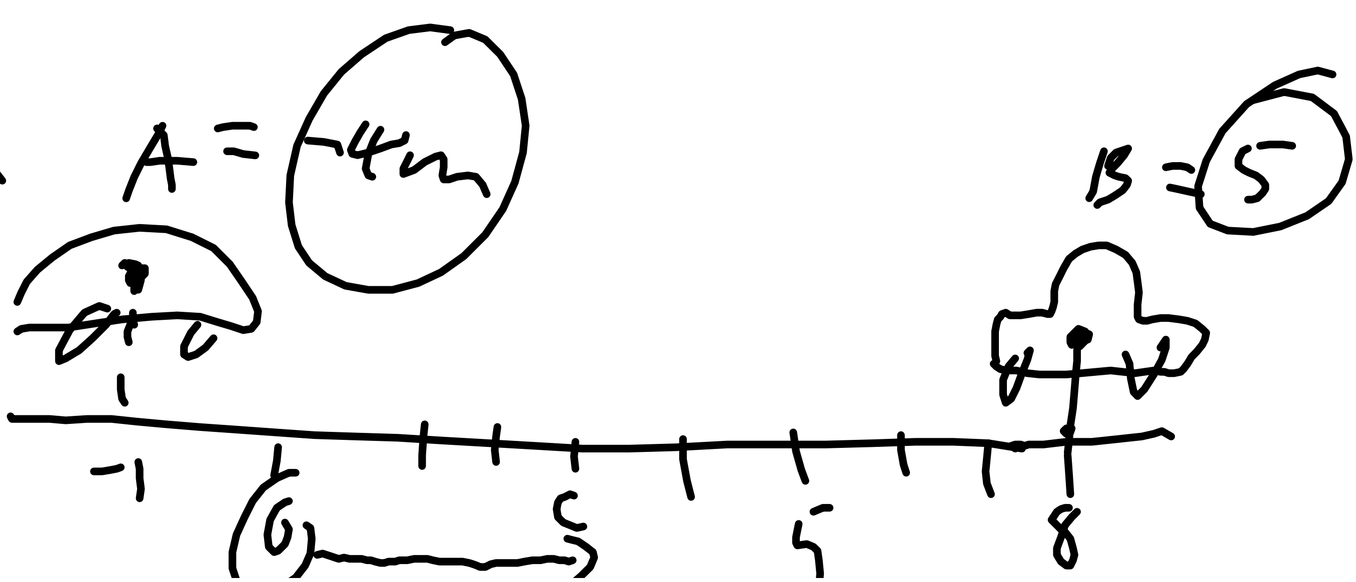
0.340

10.240

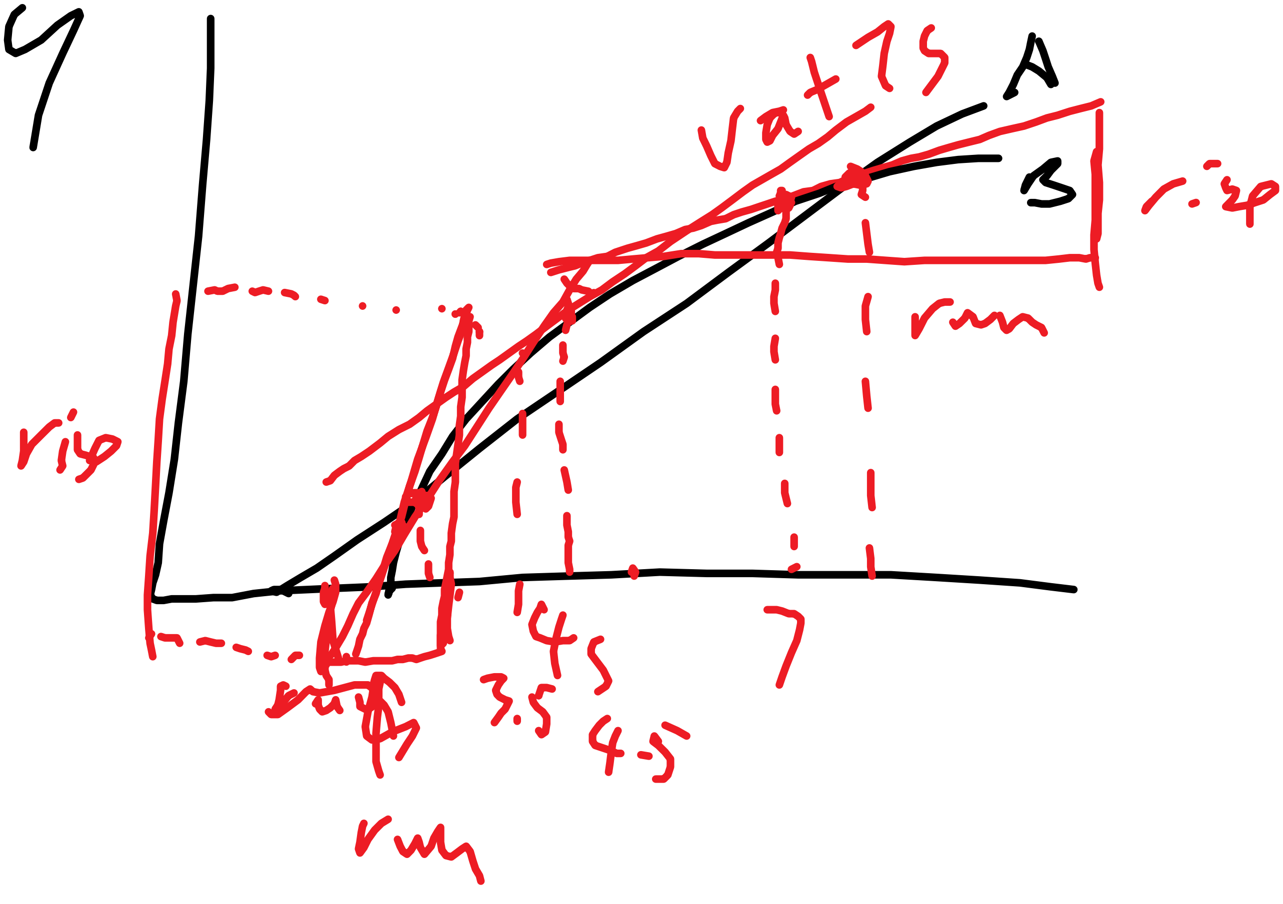
10.24 km

p58
AC 1

p4#2



Q4

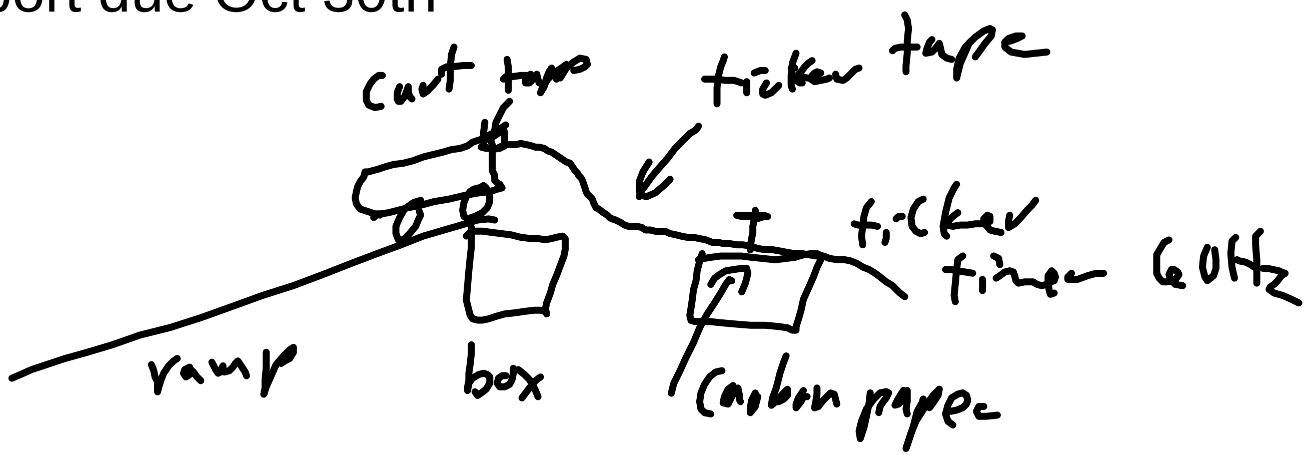


Sin(50)=0.766044443118978
49/0.7660444=63.9649608
sqrt(63.965)=
7.997812200845929

Monday, October 19, 2015
8:49 AM

Cart rolling down slope lab p22 online lab manual

full report due Oct 30th



d_2 starts at 0

1 tape/student

d (cm)	t (s)	t^2 (s^2)
0	0	0
0.50	0.1	0.01
1.50	0.2	0.04
3.50	0.3	0.09

for Monday October 26, graph d-t and d-t^2

Out in the lab, one student catches the cart

(3.50 − 1) = 0.5

Out in the lab, one student catches the cart

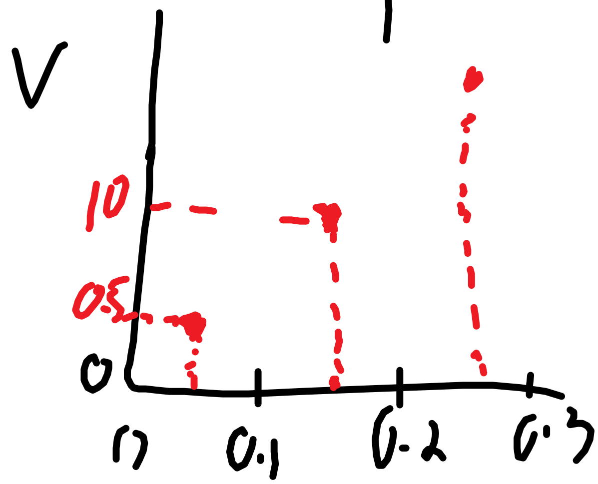
$0.50 - 0 = 0.5$

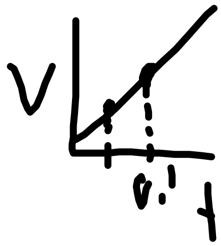
$\Delta d_1 = d_2 - d_1 = 1.50 - 0.50$

$\Delta d_2 = 3.5 - 1.5 =$

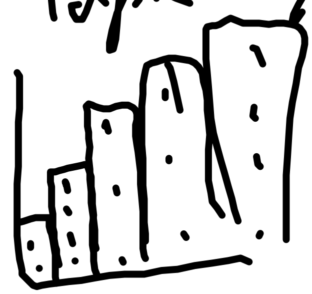
	t	Δd	V_{avg} (cm/s)
half way →	0.05	0.5 → ÷0.1 =	5.0 cm/s
		1.0 → ÷0.1 =	10
		2.0 → ÷0.1	20

V_{avg} − t graph due Oct 28





+ cut up ticker tape + glue



Quiz:

1. v=d/t t=d/v = moon 3.84×10^8m/3.00×10^8m/s
   t=1.28s
   sun 1.50×10^{11}m/3.00×10^8m/s = 500s
   5.00×10^2s
2.

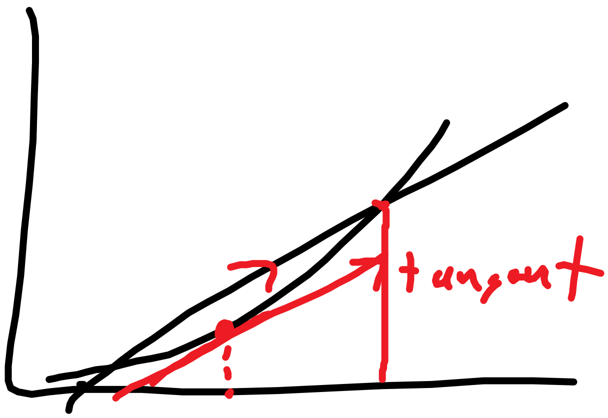
a) speed = slope at any point (185m-0)/(17s-0)
   185/17=10.8824 = 11m/s
   22m/s

b) average speed= total d/total t

= 180m/14s 180/14=12.8571   13m/s
26m/s

c) slope of the tangent to the curve shows the instantaneous speed.

4.0s is the best estimate

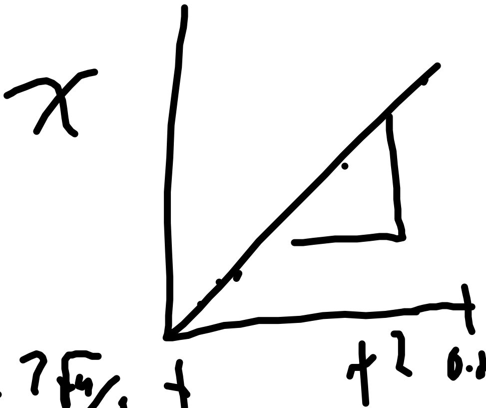


d) 160m-60m/(13s-7s)
100/6=16.6667

slope at that point
17m/s or 34m/s

3

x				
t	0	0.16	0.20	
t^2	0	0.01	0.04	. . .



Slope = $2.0\,m/s^2$ or $4.0\,m/s^2$

$y = mx + b$

$$x = 2.0\,m/s^2\, t^2$$

or $$x = 4.0\,m/s^2\, t^2$$

or

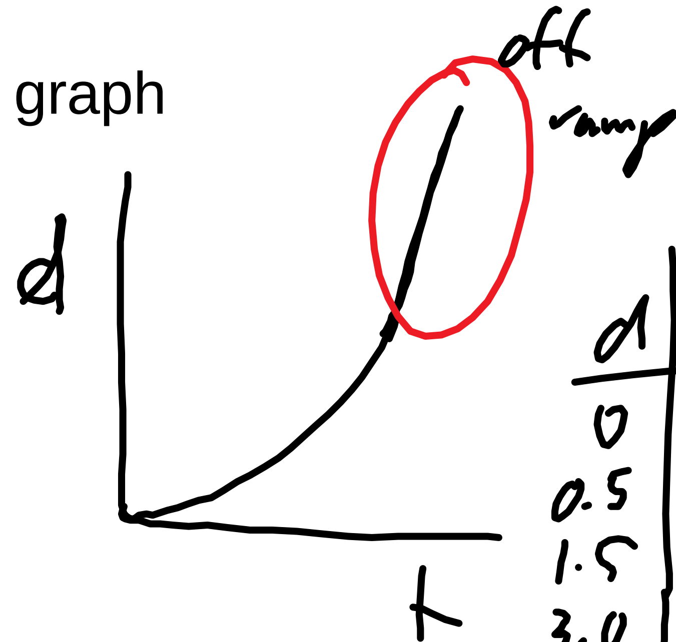
$\sqrt{x} = 1.7\,\sqrt{m}/s\; t$

$\sqrt{x} = 2.0\,\frac{\sqrt{m}}{s}\; t$

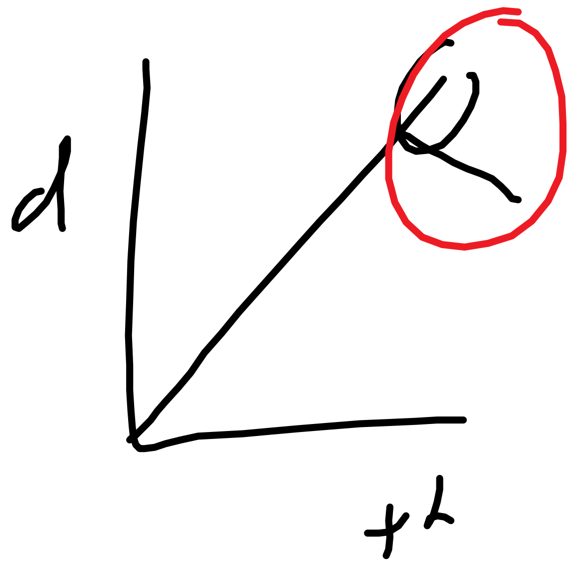
Block 2-1
Uniform Acceleration

Lab - cart on the slope

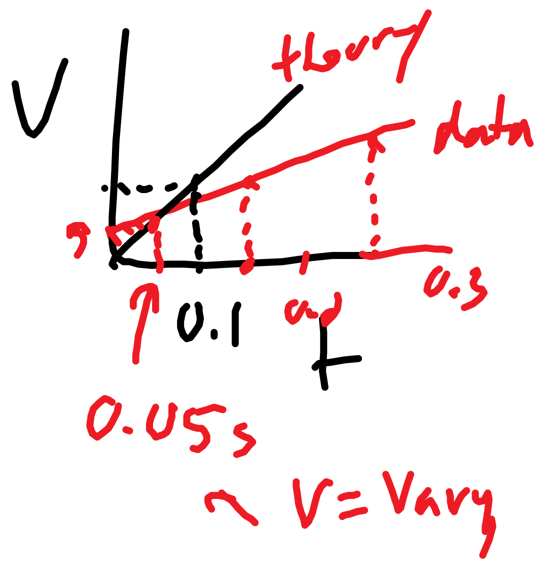
d-t graph

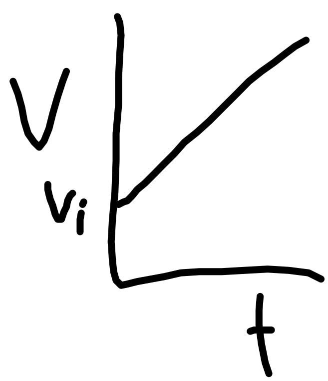


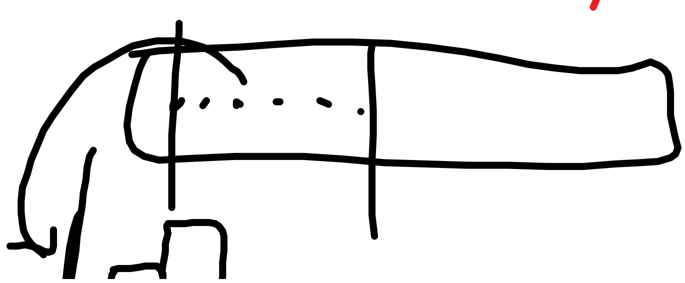
d	t
0	0
0.5	0.1
1.5	0.2
3.0	0.3

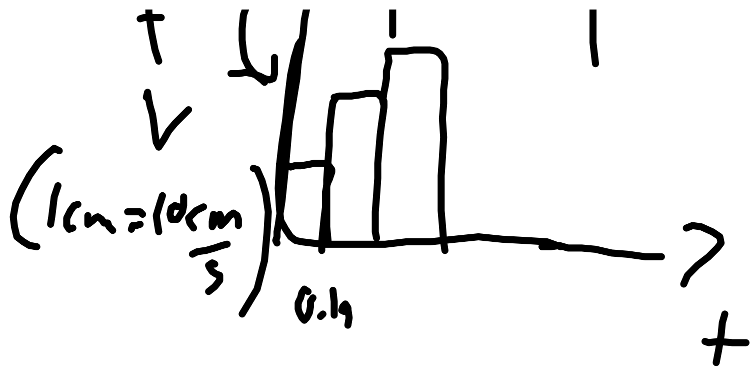


t	Δd	v
0.05	0.5 ÷ 0.1	= 5
	1.0	10
	1.5	15



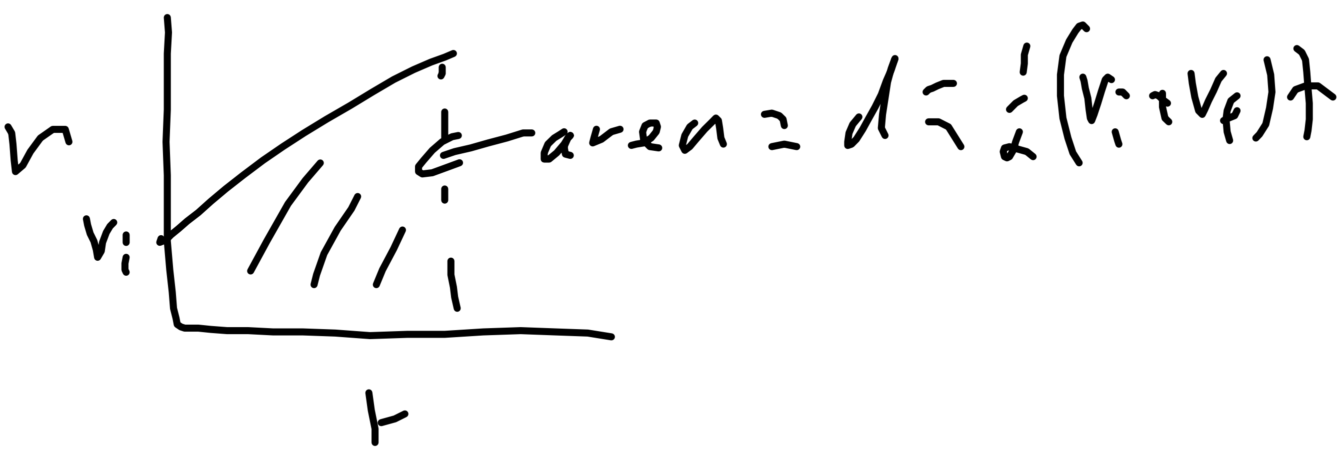






Lab will have
title, name, block, purpose, hypothesis, observations (data tables with units and proper sig figs), analysis 4 graphs, d-t, d-t^2, v-t, ticker tape cut up, and answers to the question on p22 in lab manual, conclusion, sources of uncertainty
due Friday

Theory:
acceleration, $a=\Delta v/\Delta t$ rate of change in velocity
slope of v-t graph
$v_f=at+v_i$



using math skills combine the two equations to make two new equations

5 variables: d, v_i, v_f, t, a

what if you have a problem that requires an equation relating: v_f, a, v_i, t you use $v_f=at+v_i$

how about: d, v_i, v_f, t $d=1/2(v_i+v_f)t$

derive equations relating

a) d, v_i, t, a

b) d, v_i, v_f, a

solve: a) you drop a ball on the moon and it falls 1.5m with an acceleration of 1.6 m/s^2. How much time does it take?

b) what is the final velocity of the ball?

solve p72-75 Q13-24

derive equations relating

a) d, v_i, t, a no v_f

$d=1/2(v_i+v_f)t$ $v_f=at+v_i$

$d=1/2(v_i+at+v_i)t$

$d=1/2at^2 + v_it$

lab: include this equation for hypothesis

b) d, v_i, v_f, a no t

$d=1/2(v_i+v_f)t$ $v_f=at+v_i$ $t = (v_f-v_i)/a$

$d=1/2(v_i+v_f)(v_f-v_i)/a$

$2ad = (v_i+v_f)(v_f-v_i) = v_f^2 +v_iv_f -v_iv_f -v_i^2$

$$2ad = (v_i+v_f)(v_f-v_i) = v_f^2 + v_iv_f - v_iv_f - v_i^2$$

$$2ad = v_f^2 - v_i^2$$

$$v_f^2 = v_i^2 + 2ad$$

$v_i = 0$ if drop or from rest

$d = 1.5\text{ m}$

$a = 1.6\text{ m/s}^2$

$t = ?$

$$d = \frac{1}{2}at^2 + v_it \quad (v_i t \to 0)$$

$$2d = at^2$$

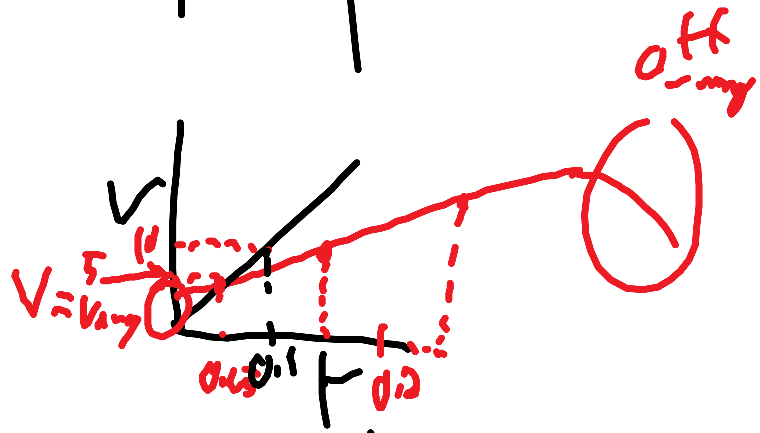
$$\frac{2d}{a} = t^2$$

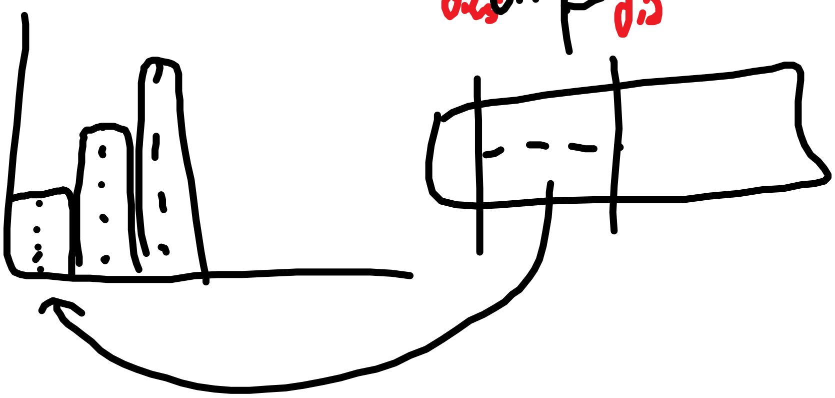
$$t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2(1.5\text{ m})}{1.6\text{ m/s}^2}} = 1.4\text{ s}$$

Block 2-2
Lab Graphs

d (cm)	t (s)
0	0
0.5	0.1
1.5	0.2
3.0	0.3

t (s)	Δd (cm)	v (cm/s)
0.05	0.5 ÷ 0.1	= 5
0.15	1.0	10
0.25	1.5	15

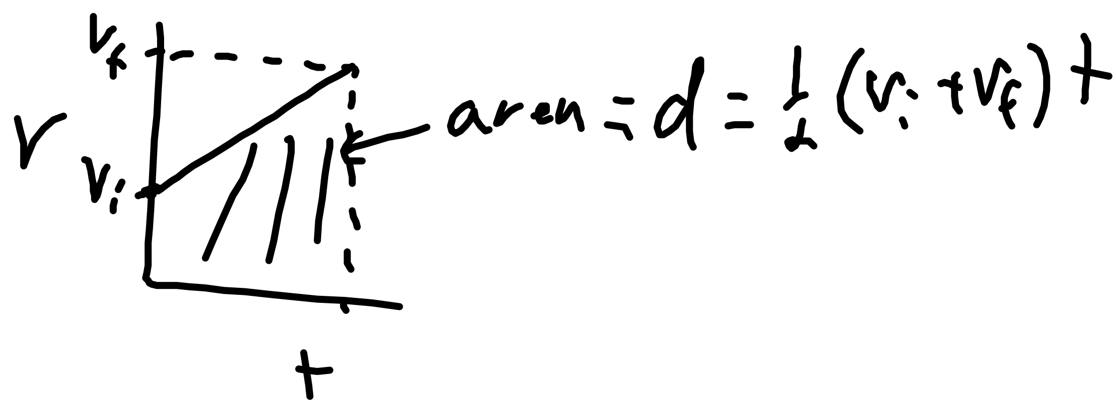




Lab due Friday
title, name, block,
purpose:
Hypothesis: - talk about today
procedure: write "refer to lab manual p22"

observations: data tables with units and proper sig figs
analysis:
4 graphs, d-t, d-t^2, v-t, ticker tape
d-t^2 and v-t graphs need equations
p22 in lab manual - answer the questions
conclusion,
sources of uncertainty

Theory:
acceleration, $a=\Delta v/\Delta t$ rate of change in velocity, slope of the v-t graph
if a is constant, then v-t graph is linear



using math skills combine the two equations to make two new equations
5 variables: d, v_i, v_f, t, a
If you have a problem that requires an equation relating: v_f, a, v_i, t
you use $v_f=at+v_i$

how about: d, v_i, v_f, t $d=1/2(v_i+v_f)t$

1. derive equations relating
   d, v_i, t, a no v_f
   d, v_i, v_f, a no t

   solve: a) you drop a ball on the moon and it falls 1.5m with an acceleration of 1.6 m/s^2. How much time does it take? what is the final velocity of the ball?

   p72-75 q13-24

$d=1/2(v_i+v_f)t$ sub $at+v_i$ in for $v_f=at+v_i$

$d=1/2(v_i+at+v_i)t$

$d=v_it + 1/2at^2$

$d=1/2(v_i+v_f)t$ sub $t=(v_f-v_i)/a$

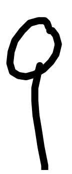
$d=1/2(v_i+v_f)(v_f-v_i)/a$

$2ad = (v_i+v_f)(v_f-v_i) = v_f^2 +v_iv_f-v_fv_i -v_i^2$

$2ad = v_f^2-v_i^2$

$v_f^2 =v_i^2 + 2ad$

$v_i = 0$ (drop, from rest)



$a = 1.6 m/s^2$

$d = 1.5\,m$ | $a = 1.6\,m/s^2$

$t = ?$

$d = v_i t + \frac{1}{2} a t^2$ ($v_i \to 0$)

$d = \frac{1}{2} a t^2$

$2d = a t^2$

$t^2 = \frac{2d}{a}$

$t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2(1.5\,m)}{1.6\,m/s^2}}$

$t = 1.4\,s$

b) $v_f = ?$, $v_i = 0$, $a = 1.6\,m/s^2$

$d = 1.5\,m$

$v_f^2 = v_i^2 + 2ad$

$v_f^2 = 0^2 + 2(1.6\,m/s^2)(1.5\,m)$

$v_f = \sqrt{4.8\,m^2/s^2}$

$$v_f = \sqrt{48\ m^2/s^2}$$

$$= \boxed{6.9\ m/s^2}$$

Block 2-1

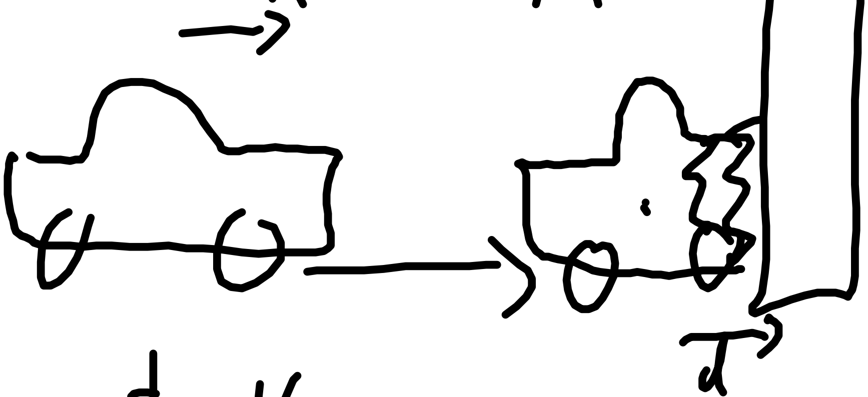
Quiz Nov 5
Each question is out of 2 marks-
0.5 to write down the information
(sometime a diagram/picture helps)
0.5 for the correct equation
0.5 for subbing in correctly
0.5 for answer

$101\,\frac{km}{h}\left(\frac{1000\,m}{1\,km}\right)\left(\frac{h}{3600\,s}\right) = 28.06\,m/s$

eg. p75 q23

$v_i = 101\,km/h$

$a = -300\,m/s^2$



$v_f = 0$

$v_f = at + v_i$

$d = \frac{1}{2}(v_i + v_f)t$

$d = \frac{1}{2}at^2 + v_i t$

$v_f^2 = v_i^2 + 2ad$

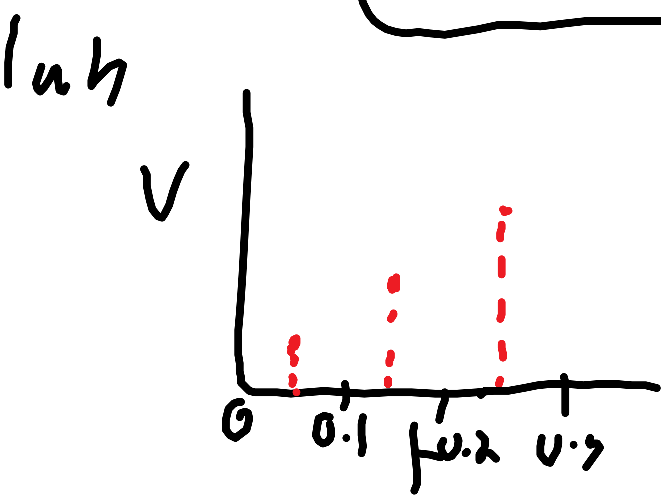
$0 = 28.06^2\,m^2/s^2 + 2(-300\,m/s^2)d$

$0 = (28.06\,m/s)^2 + 2(-300\,m/s^2)d$

$$-787.36\,\frac{m}{s^2} = +600\,\frac{m}{s^2}\,d$$

$$d = \frac{757.36}{600}\,m$$

$$\boxed{d = 1.31\,m}$$

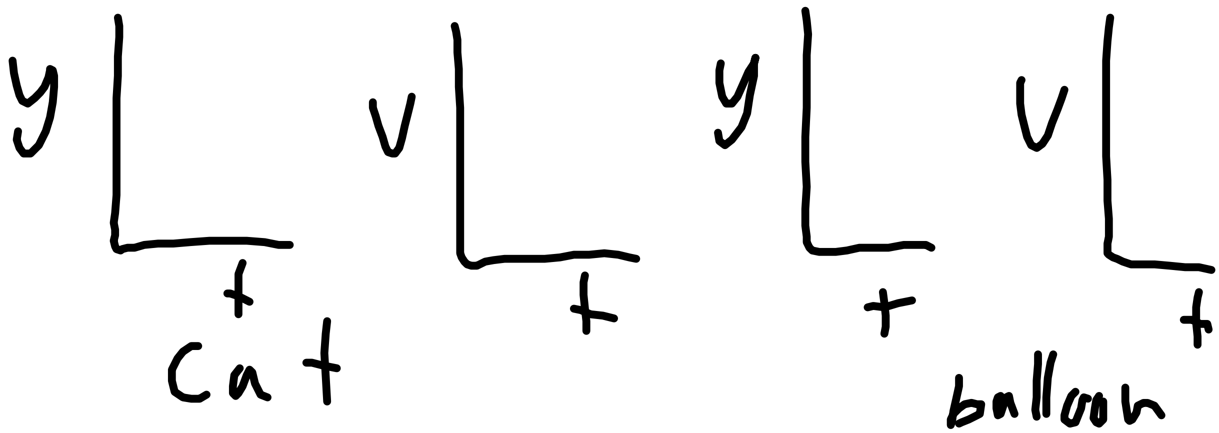


middle of time intervals

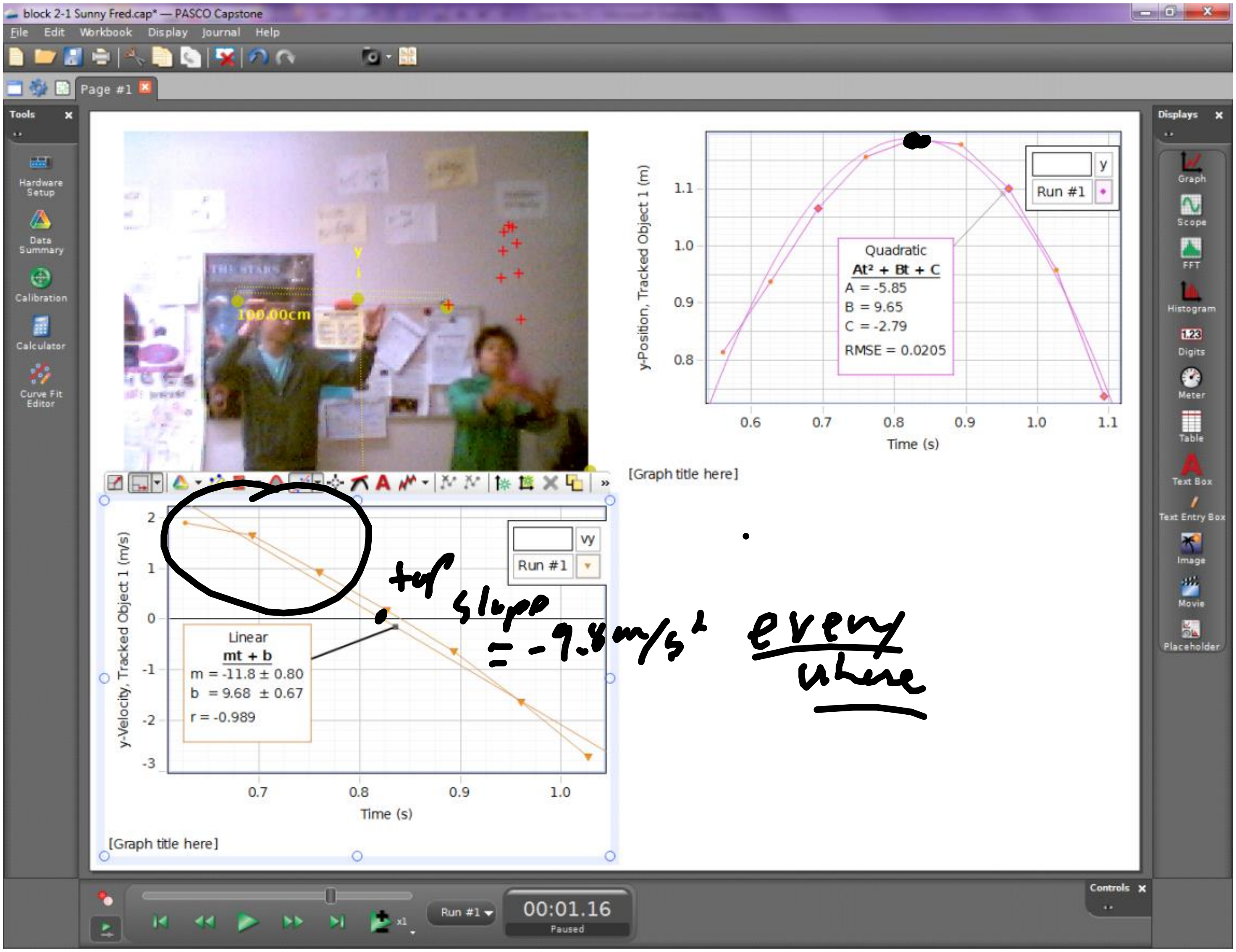
Acceleration due to Gravity
Demo:
movie of two projectiles launched vertically
1. a stuffed cat 2. a balloon

use a program: "capstone" to determine the position at regular time intervals (each picture frame is at a set frequency - 20frames/second)

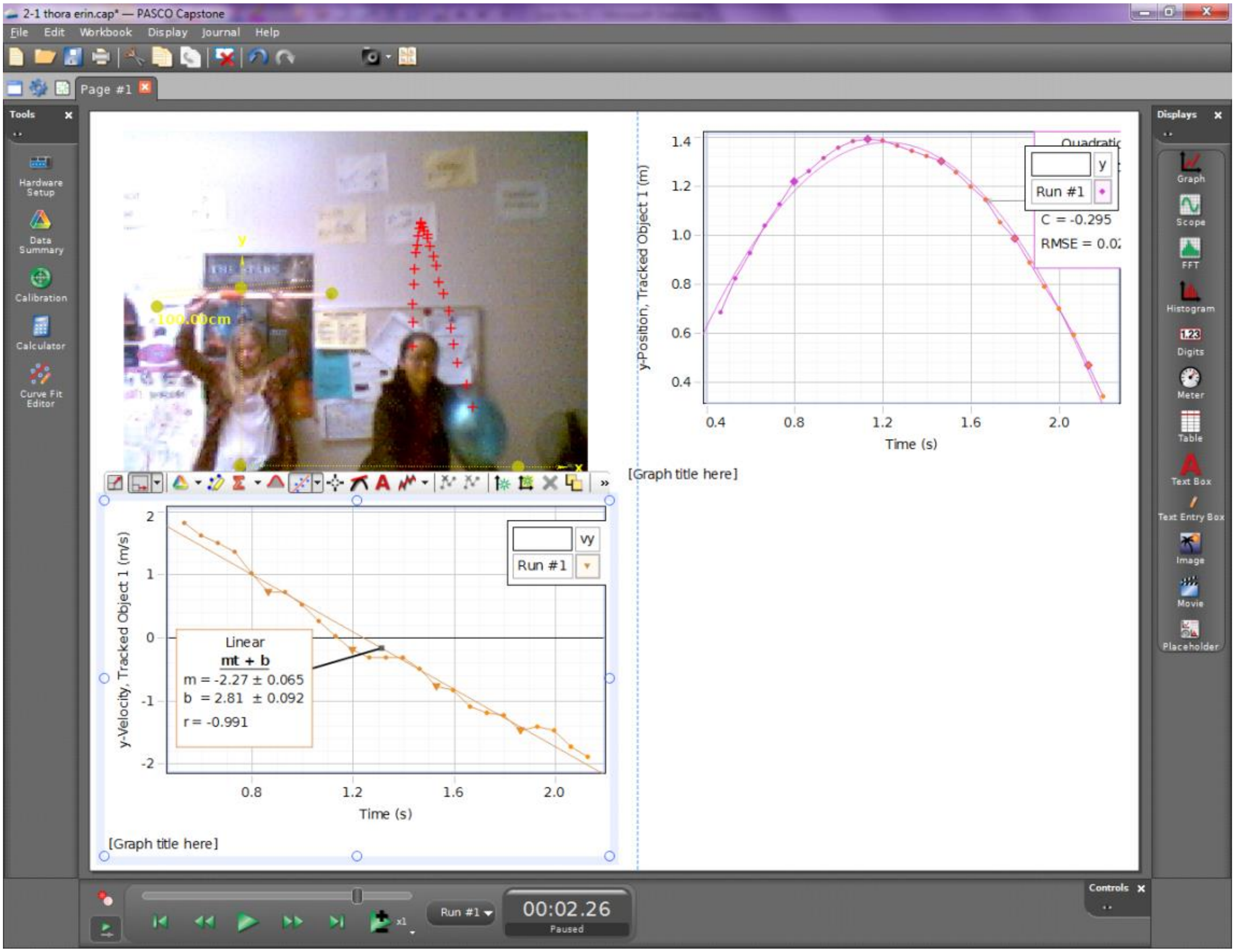
graph the y-t and v-t data
predict the shape of the graphs



a student will throw each object up while we record the data.



block 2-1 Sunny Fred.cap* — PASCO Capstone
File Edit Workbook Display Journal Help
Page #1
Tools
Hardware Setup
Data Summary
Calibration
Calculator
Curve Fit Editor
100.00cm
y-Position, Tracked Object 1 (m)
Time (s)
y
Run #1
Quadratic
At² + Bt + C
A = -5.85
B = 9.65
C = -2.79
RMSE = 0.0205
[Graph title here]
y-Velocity, Tracked Object 1 (m/s)
vy
Linear
mt + b
m = -11.8 ± 0.80
b = 9.68 ± 0.67
r = -0.989
top
slope = -9.8 m/s²
every where
Displays
Graph
Scope
FFT
Histogram
Digits
Meter
Table
Text Box
Text Entry Box
Image
Movie
Placeholder
Controls
Run #1
00:01.16
Paused



Shape of the graphs:
y-t graph is a parabola
v-t graph is linear with a negative slope

theoretical slope? v-t is acceleration
if there is no air resistance $a=g=-9.80 m/s^2$

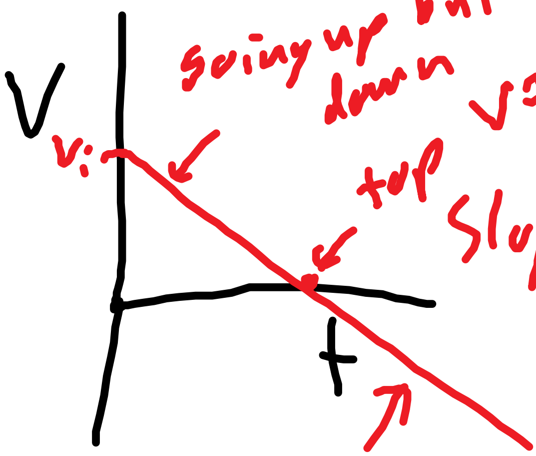
in our videos, there is scaling problems
because of the metre stick not being

perfectly in the plane of the projectile.

$$y = \frac{1}{2} g t^2 + V_i t$$

↑ $-9.8\ m/s^2$

$$y = \frac{1}{2}(-9.8\ m/s^2)t^2 + V_i t$$



going up but slowing down

$v = 0$ $a = -9.80\ m/s^2$

top

Slope = $-9.80\ m/s^2$

$$V = -9.8\ m/s^2\ t + V_i$$

Speeding up as it falls

eg. you throw a cat up in the air (ignore air resistance) with a speed of 2.5 m/s.

a) how high does it go?

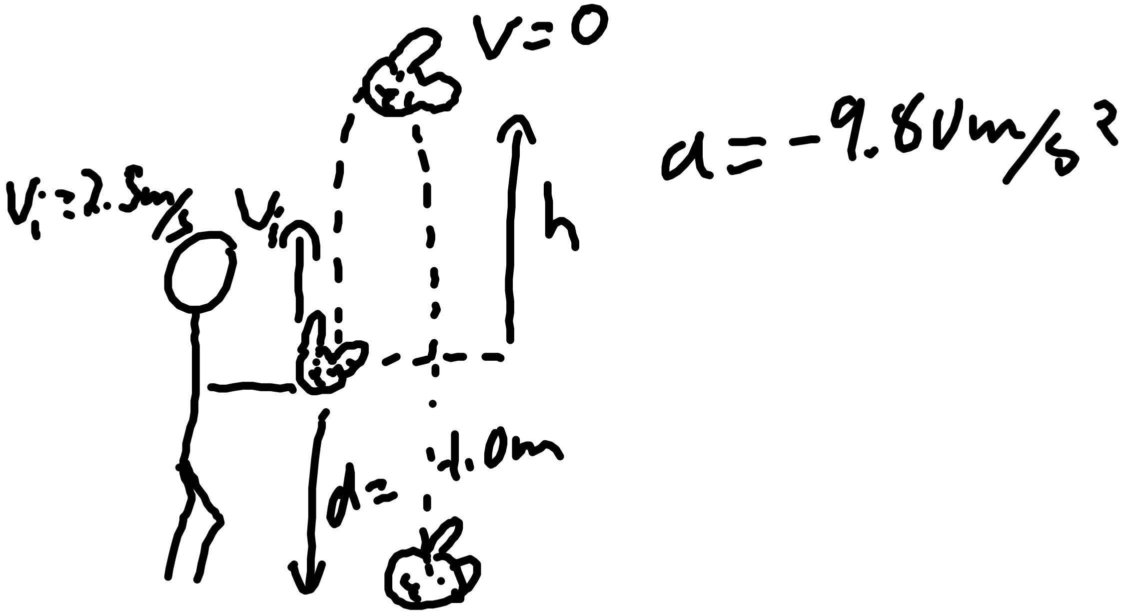
b) how long does it take to reach

i) max height

ii) back to the same height

iii) bonus: floor 1.0m below the throw point

c) speed just before hitting the floor



$$V_f = at + V_i$$

$$d = \frac{1}{2}(V_i + V_f)t$$

$$d = \frac{1}{2}at^2 + V_i t$$

$$V_f^2 = V_i^2 + 2ad$$

a) $h = ?$ $V_i = 2.5 m/s$ $V_f = 0$

$a = -9.80 \, m/s^2$

$V_f^2 = V_i^2 + 2ad$

$0 = (2.5 \, m/s)^2 + 2(-9.8 \, m/s^2)h$

$h = \dfrac{-6.25 \, m^2/s^2}{-19.6 \, m/s^2}$

$h = 0.3188 \, m = \boxed{0.32 \, m}$

save for later

b) $V_f = at + V_i \qquad t = \dfrac{V_f - V_i}{a}$

i) $t = \dfrac{0 - 2.5 \, m/s}{-9.8 \, m/s^2} = 0.2551 \, s$

$\boxed{0.26 \, s}$

ii) $t_{up} = t_{down}$

$2 \times 0.2551 \, s = \boxed{0.51 \, s}$

...ded

unrounded

ii) 2 solutions 1- $d = \frac{1}{2}at^2 + v_i t$

$-1.0m = \frac{1}{2}(-9.8)t^2 + 2.5t$

$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

2) total drop = 1.0m + 0.3188m

$V_i = 0$ $d = \frac{1}{2}at^2 + \cancel{v_i t}^{\to 0}$

$-1.3188m = \frac{1}{2}(-9.8 m/s^2)t^2$

$t_{down} = 0.51879 s$

$t_{up} + t_{down} = 0.2551s + 0.5187s$

$t = 0.7739s$

$= \boxed{0.77s}$

c) $V_f^2 = V_i^2 + 2ad$

$d \neq$ distance travelled

$= \Delta$ position

$= -1.0\,m$

$$V_f^2 = (2.5\,m/s)^2 + 2(-9.8\,m/s^2)(-1.0\,m)$$

$$V_f^2 = 6.25\,\frac{m^2}{s^2} + 19.6\,m^2/s^2$$

$$V_f = \sqrt{25.85\,\frac{m^2}{s^2}}$$

$$\boxed{V_f = 5.1\,m/s}$$

p77-80 q25-32, CR 2.1-2.4 due Tuesday

Lab due next class and bring usb

Block 2-2

Quiz Nov 5 Acceleration
Lab is due next class
bring a usb (or computer with capstone program)

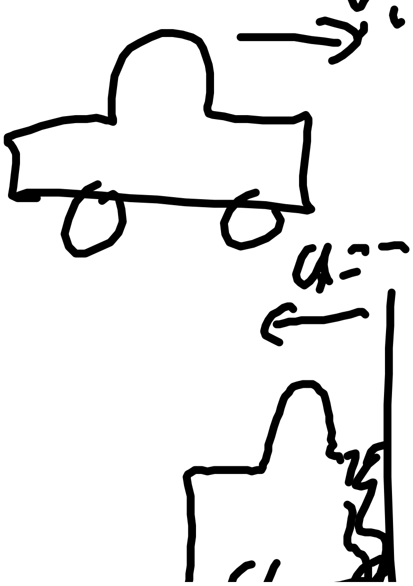
marking for the quiz:
each question out of 2 marks
0.5 mark for writing down the information in the question - diagram can sometimes help v_f = ___ v_i=___d=____a=____t=__

0.5 mark for equation relating variables
0.5 mark for sub in
0.5 mark for the answer

eg. p75 Q23

$v_i = 101\ \text{km/h}\left(\frac{1000\ \text{m}}{\text{km}}\right)\left(\frac{\text{h}}{3600\ \text{s}}\right)$
$= 28.06\ \text{m/s}$

use unrounded values



$a = -304\ \text{m/s}^2$

wall

$v_f = 0$

$v_f = v_i + at$

$d = \frac{1}{2}(v_i + v_f)t$

$v_f = 0$

$\vec{d} = ?$

$d = \frac{1}{2}at^2 + v_i t$

$$v_f^2 = v_i^2 + 2ad$$

Sub in $0 = (28.06\,m/s)^2 + 2(-300\,m/s^2)\,d$

$-787.114\,\frac{m^2}{s^2} = -600\,\frac{m}{s^2}\,d$

$d = 1.31186\,m$

$$\boxed{d = 1.31\,m}$$

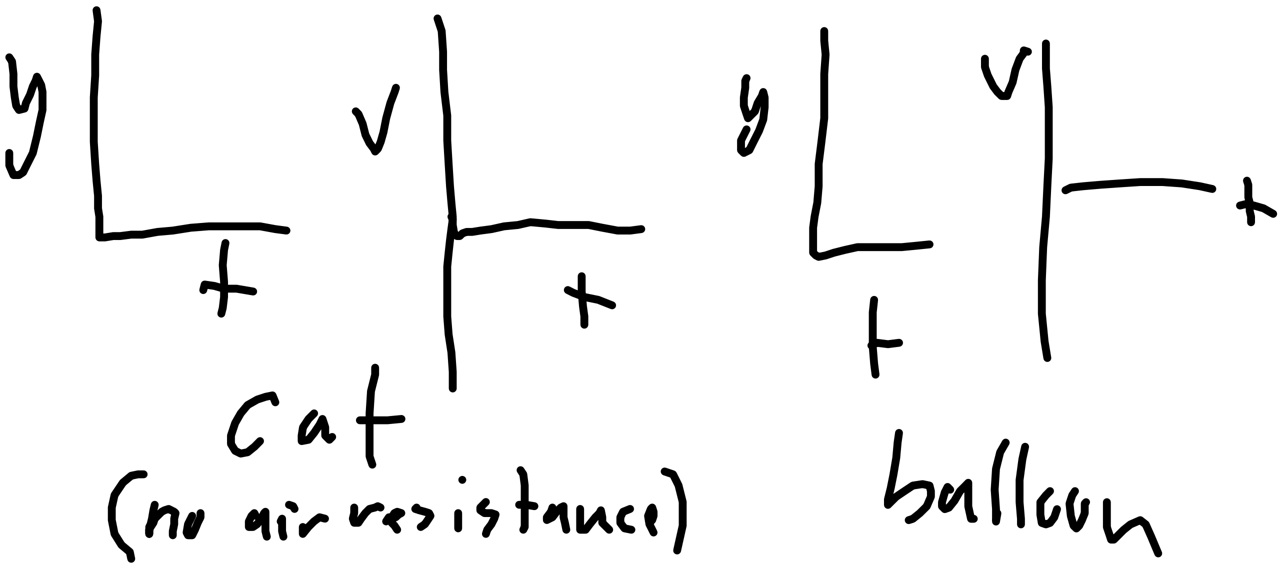
Acceleration Due to Gravity

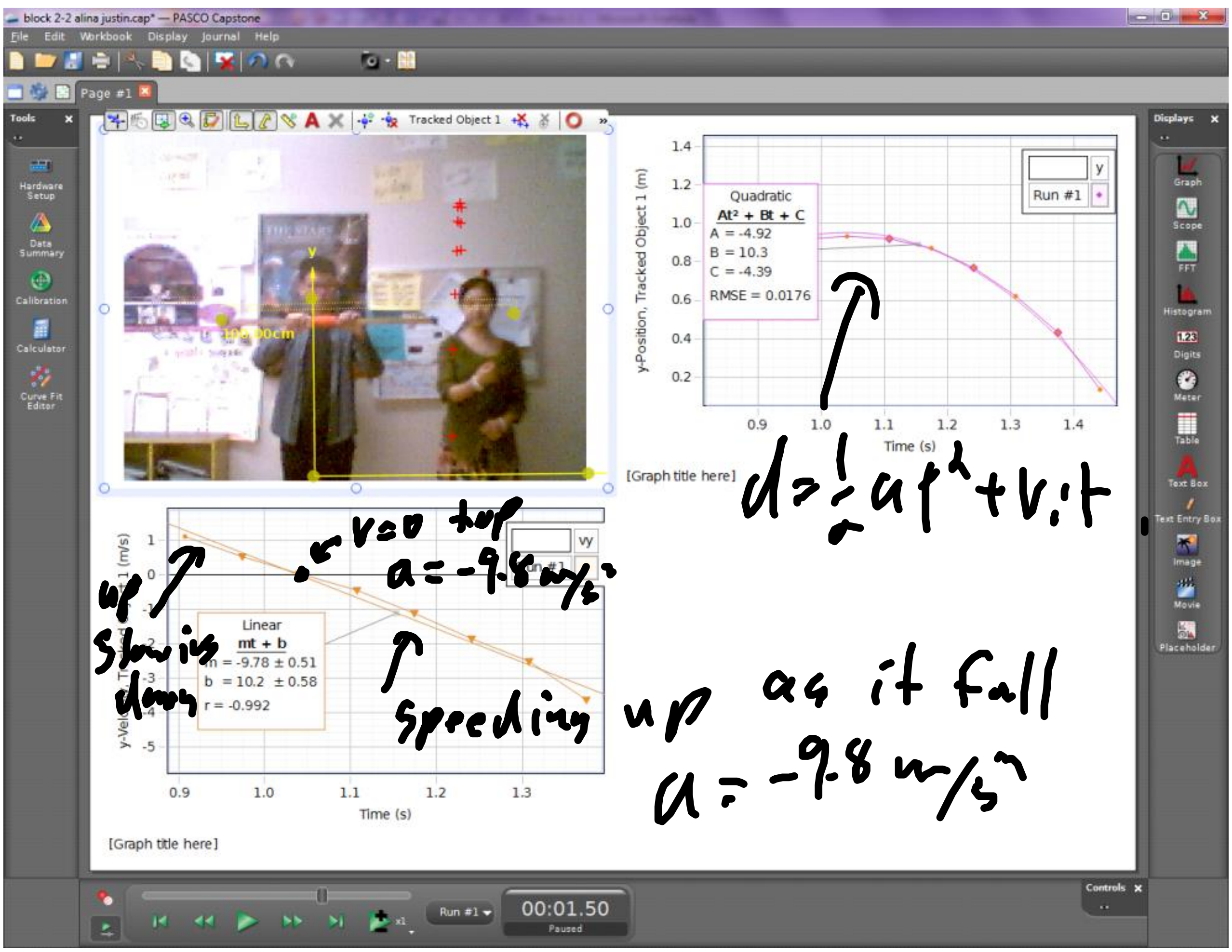
Make a movie of 2 projectiles thrown up.

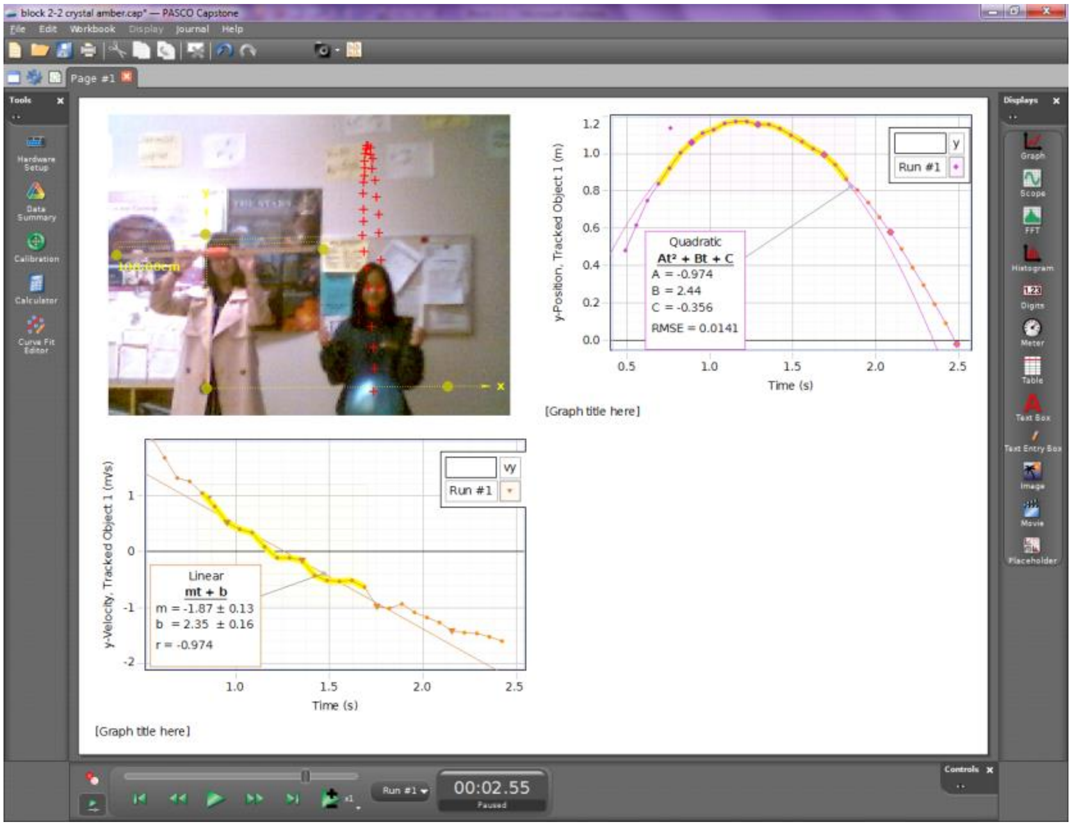
graph the y position vs t and v vs t for

1. stuffed cat 2. balloon

predict the graphs:


y
t
v
t
cat
(no air resistance)
y
t
v
t
balloon


block 2-2 alina justin.cap* — PASCO Capstone
Quadratic
At² + Bt + C
A = -4.92
B = 10.3
C = -4.39
RMSE = 0.0176
y-Position, Tracked Object 1 (m)
Time (s)
[Graph title here]
d = ½at² + vᵢt
v = 0 top
a = -9.8 m/s²
up
slowing down
Linear
mt + b
m = -9.78 ± 0.51
b = 10.2 ± 0.58
r = -0.992
speeding up as it fall
a = -9.8 m/s²
Time (s)
[Graph title here]
00:01.50



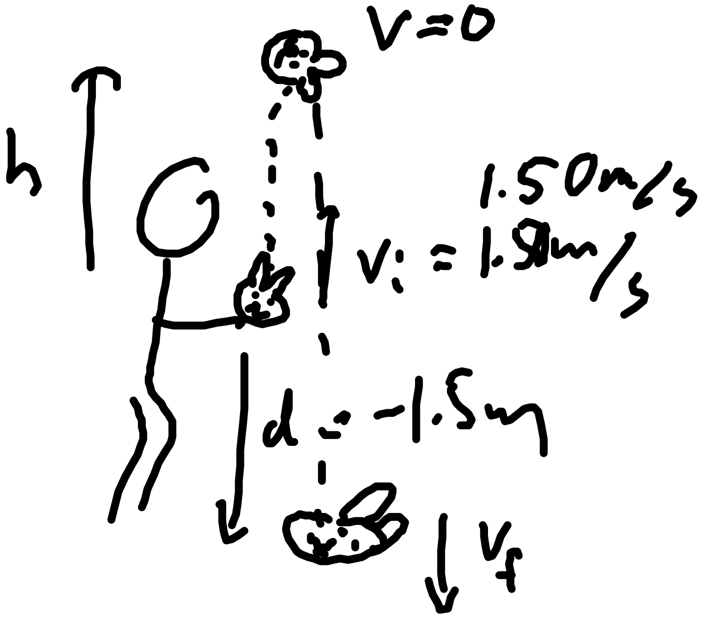
both sets of data show parabolic y-t graphs and liner v-t graphs, with the balloon having more difference at the start and end - air resistance.

Theoretically: a projectile with negligible (too small to matter) air resistance should accelerate down at $-9.80 m/s^2$.

eg. Alina throws a cat up at 1.50m/s. If air resistance is negligible, determine:

a) time to the highest point

b) height of the highest point
c) time to return to the same height
d) speed at the same height
e) speed when hitting the ground
1.5m down from throw point.
f) time when it hits the ground.



$a = -9.80\,m/s^2$

going up
at top
going down

$v_f = at + v_i$

$d = \frac{1}{2}(v_i + v_f)t$

$d = \frac{1}{2}at^2 + v_i t$

$v_f^2 = v_i^2 + 2ad$

a) $v_f = v_i + at$

$0 = 1.5 m/s + -9.80 m/s^2 \, t$

$t = 0.15306 \, s$

$\boxed{t = 0.153 \, s}$

b) $v_f^2 = v_i^2 + 2ad$

$0 = (1.5 m/s)^2 + 2(-9.8 m/s^2) h$

$h = 0.114796 \, m$

$\boxed{h = 0.115 m}$

c) $t_{up} = t_{down}$

$t = 2 \times 0.15306$

$\boxed{t = 0.306 \, s}$

$t = 0.306\ s$

d) Same t up and down
Same a
so same speed $1.50\ m/s$

e) d is displacement
NOT distance travelled

$d = -1.5\ m$

$$v_f^2 = v_i^2 + 2ad$$

$$= (1.5\ m/s)^2 + 2(-9.8\ m/s^2)(-1.5\ m)$$

$$v_f = \sqrt{2.25\ \frac{m^2}{s^2} + 29.4\ \frac{m^2}{s^2}}$$

$$v_f = 5.63\ m/s$$

f) 2 methods
1- Quadratic $d = \frac{1}{2}at^2 + v_i t$

$$-1.5 = \frac{1}{2}(-9.8)t^2 + 1.5t$$

$$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

2 - $t_{up} + t_{down}$

↑ $d + h = \frac{1}{2}at^2$

Friday, October 30, 2015
9:03 AM

O30
Hand In Lab
Redo vertical acceleration demo
work on p77-80 25-32 CR 2.1-2.4

P75
Q22

$d = 484 m$

$a = -8.0 m/s^2$

$V_i = ?$

$V_f = 0$

$V_f^2 = V_i^2 + 2ad$

$0 = V_i^2 + 2(-8 m/s^2)(484 m)$

$V_i = \sqrt{7744 \frac{m^2}{s^2}}$

$V_i = 88\ m/s$

Q30 $a = 0.20\ g$

$V_i = 0$

$V_f = ?$

$t = 2.0\ s$

g is gravitational field strength
and the acceleration of a projectile
without air resistance
$= 9.80 m/s^2$ or 9.80 N/kg
$0.2\ g \times (9.8 m/s^2/g) = 1.96\ m/s^2$
$v_f = at + v_i = 1.96 m/s^2 \times 2.0\ s = 3.92\ m/s$

g is gravitational field strength.

also the acceleration of a projectile with negligible air resistance.
$g = 9.80 m/s^2$ or $9.80 N/kg$

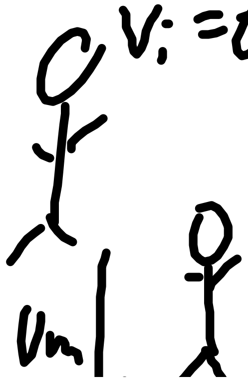
$$a = \frac{\Delta v}{\Delta t} \rightarrow v_f = a t + v_i$$

$$d = \frac{1}{2} a t^2 + v_i t \rightarrow 0$$

$$d = \frac{1}{2} a t^2$$

$v_i = 0$

$a = 9.80 m/s^2$



$d = 1.0 m$

a) $t = ?$

5) $v_f = ?$

a) $d = \frac{1}{2}at^2 + \cancel{v_i t}^{\,0}$

$$t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2(1.0\,m)}{9.80\,m/s^2}}$$

0.451754

$= \boxed{0.45\,s}$

b) $v_f^2 = v_i^2 + 2ad$

$$v_f^2 = 0 + 2(9.8\,m/s^2)(1.0\,m)$$

$$v_f = \sqrt{19.6\,m^2/s^2}$$

$$\boxed{v_f = 4.4\,m/s}$$

Q31

$v_f = 0$

$a = -9.80\,m/s^2$

$v_i = 27\,m/s$

$V_i = 27\,m/s$ [illegible]

$t = ?$

$V_f = at + V_i$

$t = \frac{-27\,m/s}{-9.80\,m/s^2}$

$= \boxed{2.8\,s}$

b) $V_f^2 = V_i^2 + 2a\underline{d}$

p80 CR 2.1
if you know v at different t,
graph the v and see if they make a linear graph

2.2 v_i, v_f, a, d=?
$v_f^2 = v_i^2 + 2ad$

2.3 $g_{Mars} = 1/3\ g_{Earth}$
a) h=?

v_i same, v_f=0, d=? a=1/3 a
$v_f^2 = v_i^2 + 2ad$
$(0-v_i^2)/2a = d$
1/ 2(9.8) = 0.051m
1/(2x9.8/3) = 0.1531 m
3 times as high

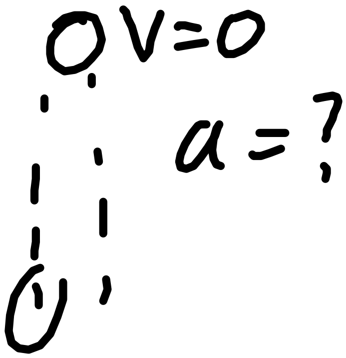
$V_f = 0 \quad V_i = \quad a = \frac{1}{3}g \quad t = ?$

$V_f = at + V_i$

$t = \frac{V_f - V_i}{}$

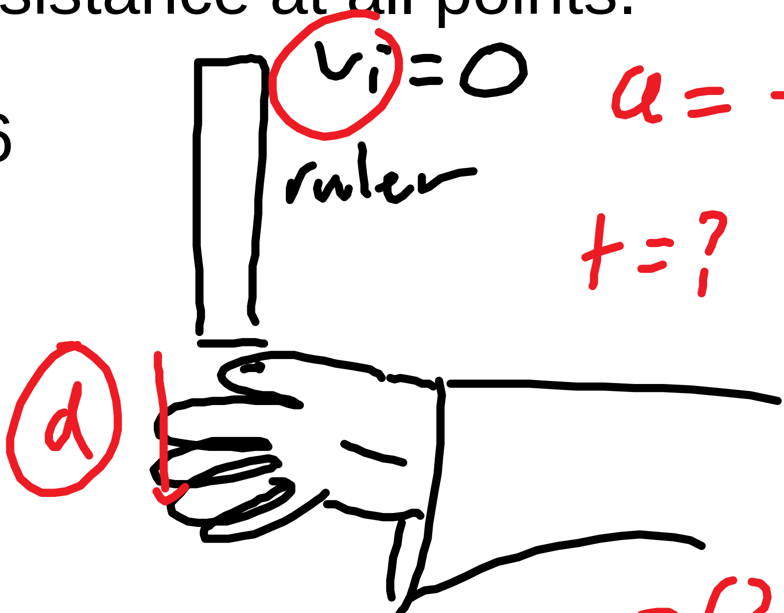
$$t = \frac{v_f - v_i}{a}$$

2.4



acceleration is $-9.80 m/s^2$ for a projectile with negligible air resistance at all points.

p79 q26



$a = -9.80 m/s^2$

$t = ?$

$d = \frac{1}{2}at^2 + v_i t$ ($v_i t \to 0$)

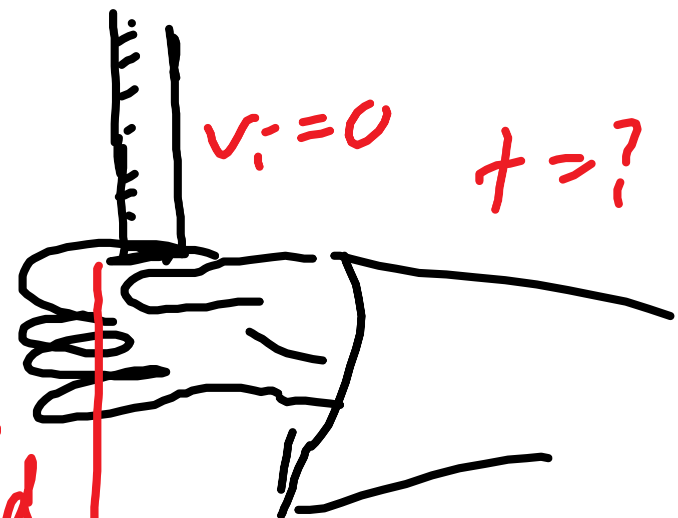
$2d = at^2$

$t^2 = \frac{2d}{a}$

$$t = \sqrt{\frac{2d}{a}}$$

$$t = \sqrt{\frac{2(0.38\,m)}{9.80\,m/s^2}} = \boxed{0.24\,s}$$

block2-2



$$d = v_i t + \frac{1}{2} a t^2 \quad (v_i t \to 0)$$

$$2d = at^2$$

$$t^2 = \frac{2d}{a}$$

$$t^2 = \frac{2d}{a}$$

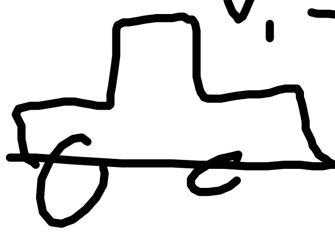
$$t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2(-0.75\,\text{m})}{-9.80\,\text{m/s}^2}}$$

$$t = 0.39\,\text{s}$$

~~P80 CK2.1~~

Q28 P85

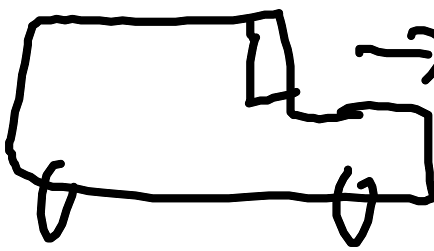
~~P79~~



$v_i = 0$

$d = \frac{1}{2}at^2$

$\vec{a} = 6.0\,\text{m/s}^2$



$v = 21\,\text{m/s}$

$a = 0$

$d = v_t t$

$t = \frac{d}{v_t}$

$$d = \frac{1}{2}at^2 = \frac{1}{2}a\left(\frac{d}{v_t}\right)^2$$

$$\cancel{d} = \frac{1}{2} a \frac{d^{\cancel{2}}}{v_f^2}$$

$$2 v_f^2 = a d$$

$$d = \frac{2 v_f^2}{a} = \frac{2 (21\,m/s)^{2}}{6\,m/s^2}$$

$$d = \cancel{7.0\,m}$$

$$d = 147\,m$$

$$d = 1.5 \times 10^2\,m$$

b) $v_f^2 = v_i^2 + 2ad$

p80

CR 2.1

v and t, is a constant?

graph v vs t and see if it is linear

2.2 v_f, v_i, a, d=?

$v_f^2 = v_i^2 + 2ad$

2.3 $g_{Mars} = 1/3\ g_{Earth}$

$v_f^2 \to 0 = v_i^2 + 2ad$

$\frac{-v_i^2}{2a} = d = \frac{-v_i^2}{2(\frac{1}{3}g)} = -3\frac{v_i^2}{2g}$

$a \leftarrow \frac{1}{3}g$

h on Earth

$d = 3h_{Earth}$

$d = \frac{(2)^2}{2(9.8)} = 0.20\ m$

$d = \frac{(2)^2}{2(\frac{1}{3}9.8)} = 0.61$

Monday, November 09, 2015
8:46 AM

p82-85
Problems: 3, 4, 7, 9, 14, 15, 20, 25, 28, 32, 33, 37
answers at: http://physics-pages.wikispaces.com/file/view/Merrill%20Ch%204.pdf/541128856/Merrill%20Ch%204.pdf
Quiz:

12, 14, 16, 18

1a) $V_i = \underline{\text{given}}$ $V_f = 20\,m/s$ $t = 4.0\,s$ $a = ?$

$V_f = at + V_i$

$20\,m/s = a(4.0\,s) + \text{given}$

← 2 sfs

$a = \frac{20 - \text{given}}{4.0} = \_\_\_\ m/s^2$

b) $d = \frac{1}{2}(V_i + V_f)\,t$

↑ given ↑ 20 ↖ 4.0 s

2. $V_i = 2.0\ m/s$ $\quad V_f = 4.0\ m/s$

$d =$ given $\quad a = ?$

$$V_f^2 = V_i^2 + 2ad$$

$V_i = 0$

$$a = \frac{V_f^2 - V_i^2}{2d}$$

$V_i = 0$

$15m = d$ $\quad a = g = 9.80\ m/s^2 \quad t = ?$

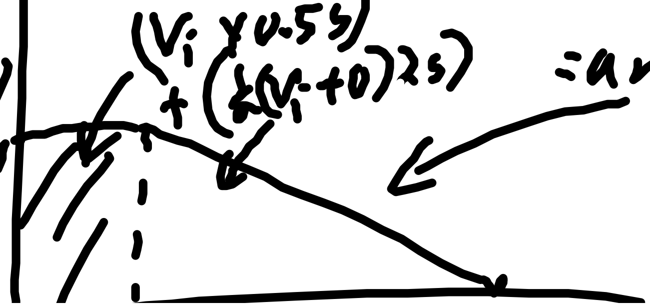
$$d = \frac{1}{2}at^2 + v_i t \rightarrow 0 \qquad t = \sqrt{\frac{2d}{a}}$$

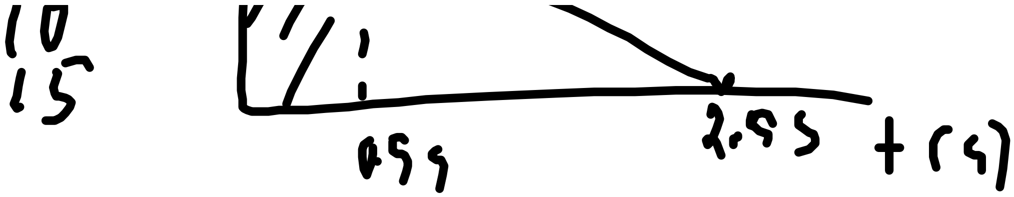
$5m =$

b) $a = ?$ $\quad t = 5.0\ s$ $\quad V_i = 0$ $\quad d =$ same

$$d = \frac{1}{2}at^2 \qquad a = \frac{2d}{t^2}$$

4 a)





3 sfs 36.0m 15.0m

12 + 24 = 36m, 15m, 27.5m

Problem 3

a=? graph slope = change in v /change in t

a= 30m/s/5s= 6.0 m/s²

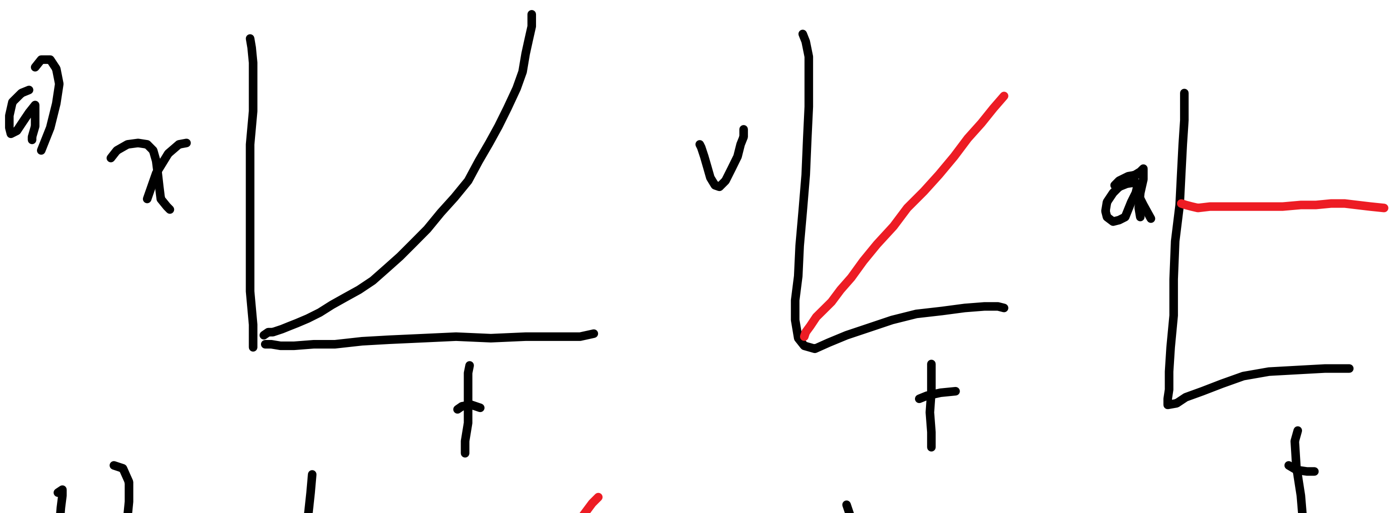
b) a=0

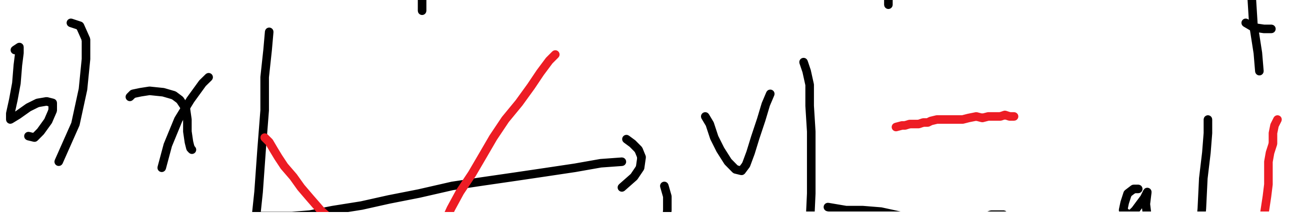
c) ~~-1.0m/s²~~ answer key says -2.0m/s²

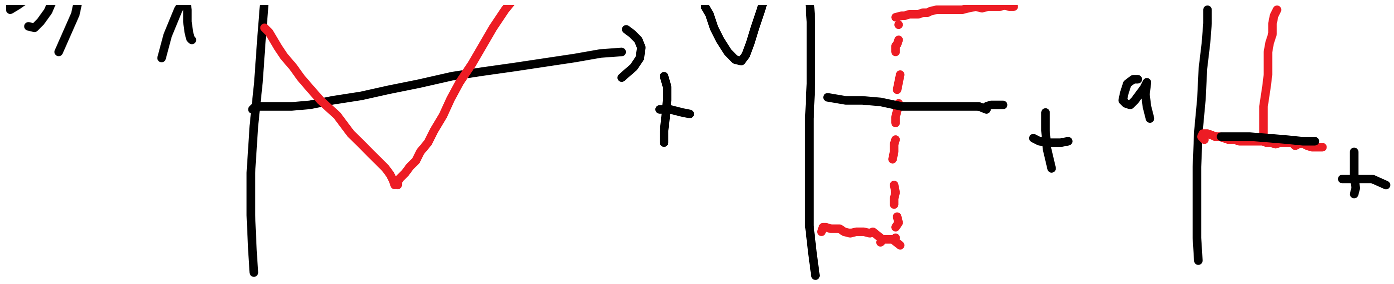
d) -4.0m/s²

4

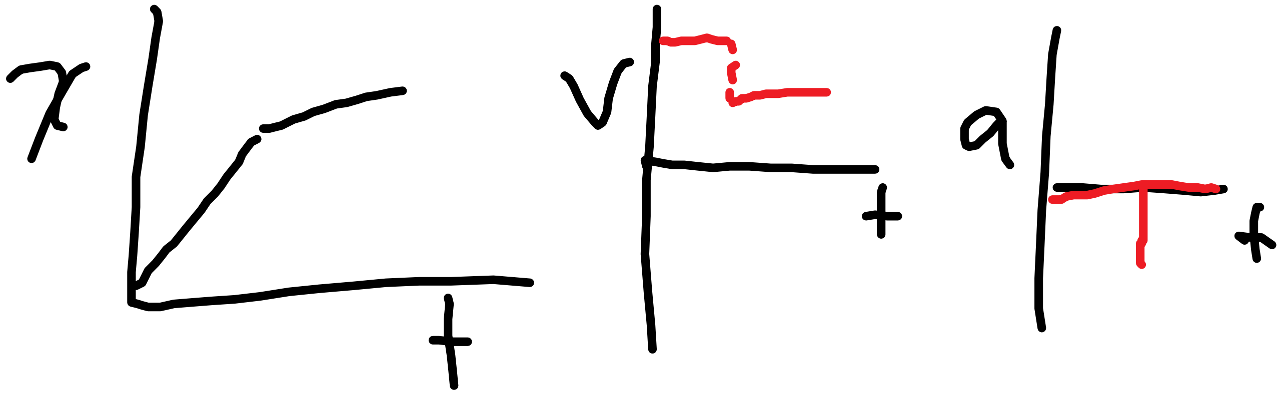
v-t a-t



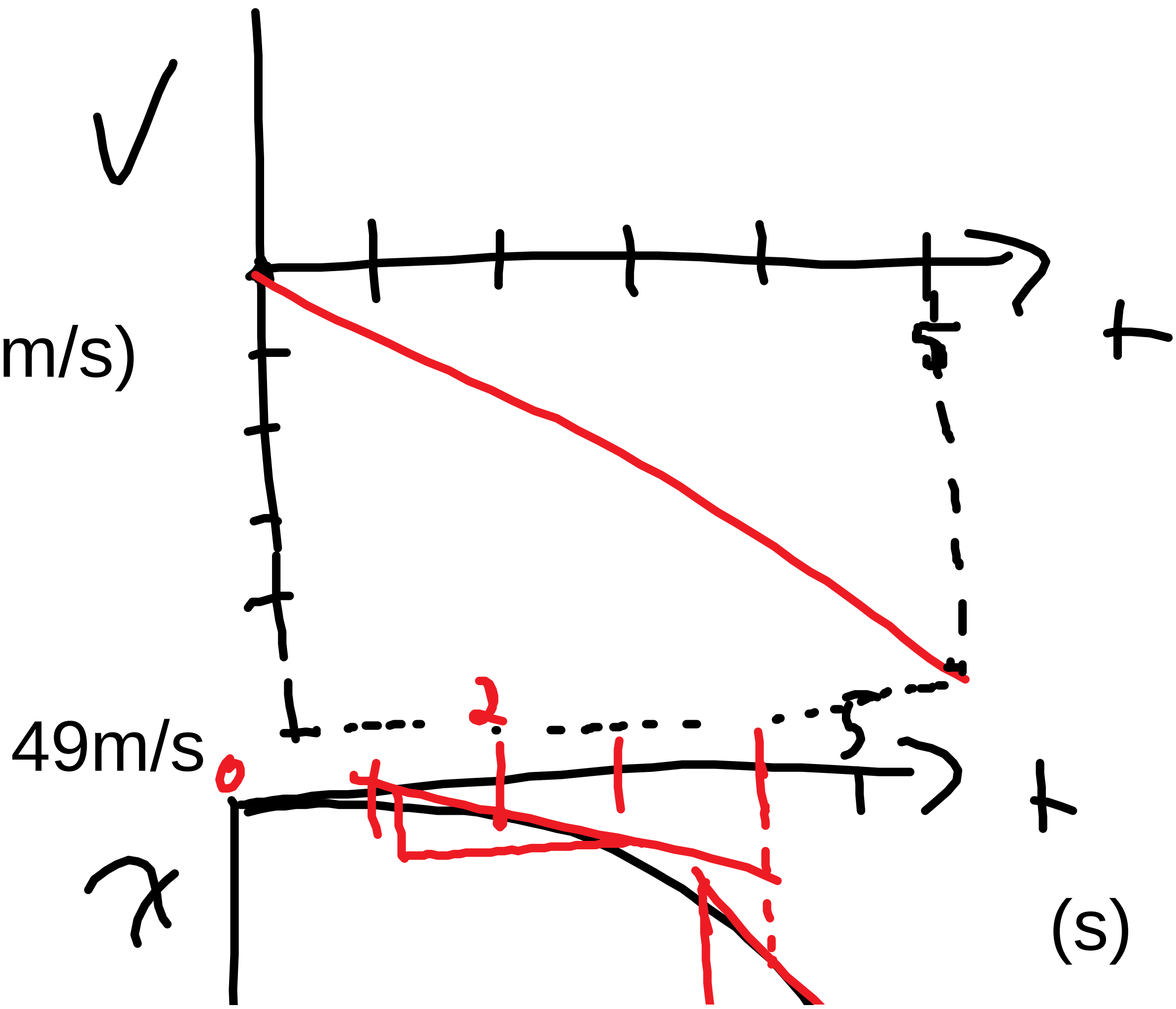


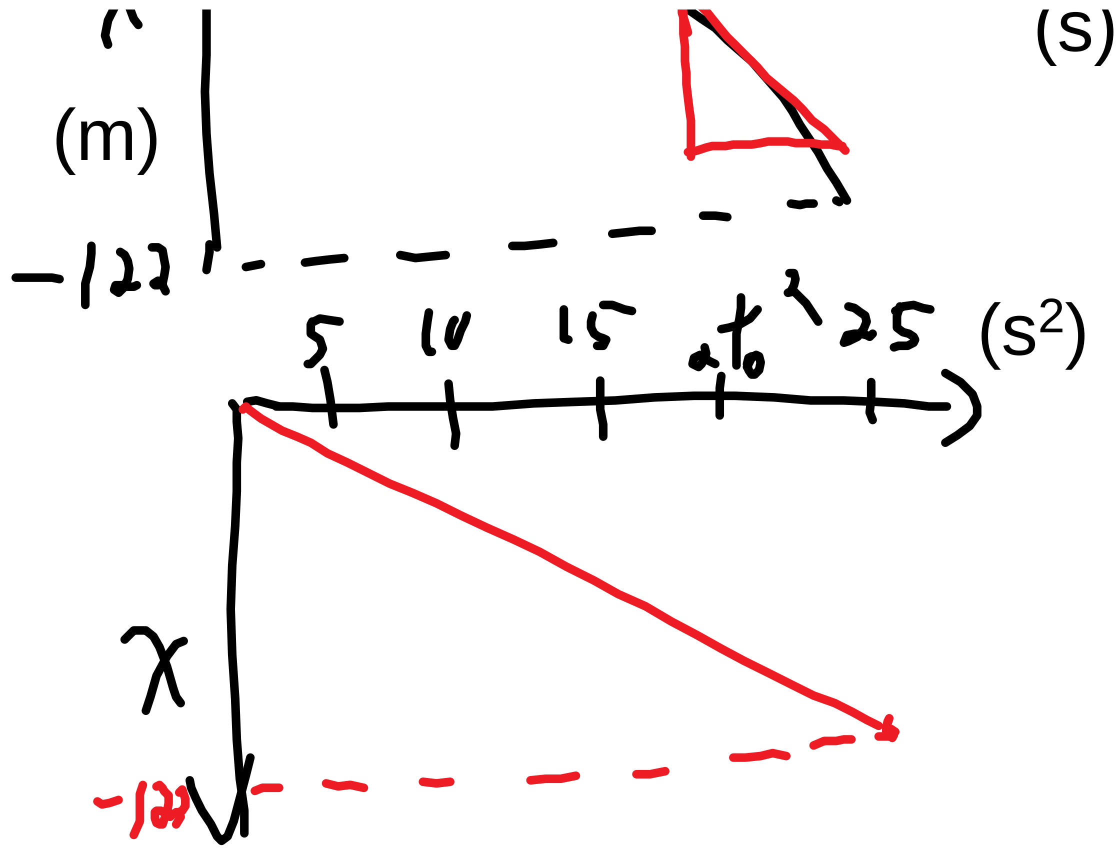


c)



Q 15





linear slope $= \frac{-122}{25} = -4.9\ m/s^2$

$= \frac{1}{2} a$

Q14

d=1.2m a=1.62 m/s^2 t=? v_i=0

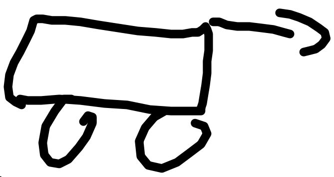
d=1/2at^2 + vit

t= root(2d/a) = sqrt(2x1.2/1.62)= 1.217161238900369

t= 1.2s

eg. You pull a 1.00 kg cart with 2.00N of force.

a) if the cart is frictionless, what is the acceleration of the cart i) while you pull it?



m = 1.0kg

$F = 2.0N \quad a = ?$

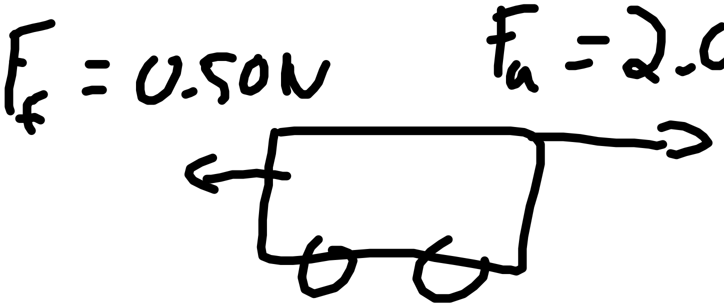
sum

$F_{net} = ma = \Sigma F$

$a = \frac{F_{net}}{m} = \frac{2.0N}{1.0kg} = \boxed{2.0 m/s^2}$

b) after you let it go?
a=0 no force so the cart will roll until it hits something

c) if the force of friction is 0.50N,
i)what is the net force on the cart if you pull it with 2.0N.



$F_{net} = F_a - F_f$

$F_{net} = 2.0N - 0.5N = 1.5N$

ii)what is the acceleration while you pull it?

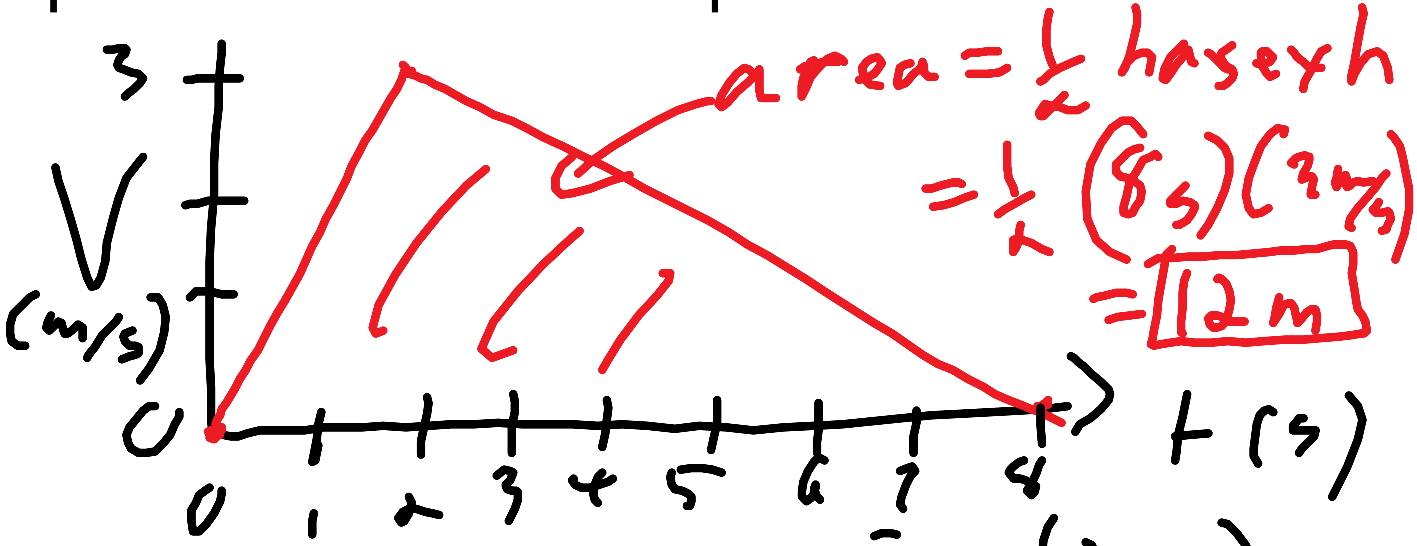
$a = \frac{F_{net}}{m} = \frac{1.5N}{1.0kg} = 1.5\ m/s^2$

iii)After you let it go?

it slows down with F_{net}=-0.50N (opposite the motion) a=Fnet/m = -0.50N/1.0kg
a=-0.50 m/s^2

iv)if you pull it for 2.0s, sketch the velocity-time graph and calculate the displacement until it stops.

displacement until it stops.



$V_f = V_i + at = 0 + 1.5\,m/s^2(2.0\,s)$

$= 3.0\,m/s$ pulling

Not pulling $V_i = 3.0\,m/s$ $V_f = 0$

$t = ?$ $a = -0.50\,m/s^2$

$V_f = V_i + at$

$0 = 3\,m/s + (-0.50\,m/s^2)\,t$

$t = 6.0\,s$

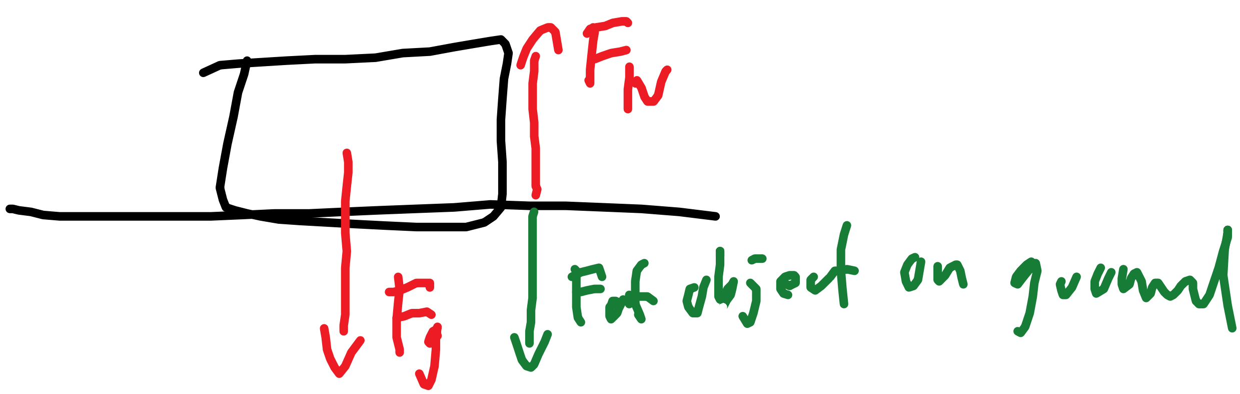
Newton's Third Law - Action-reaction Law

For every force one object (object A) acts

on another object (object B), object B responds with an equal and opposite force on object A.

eg. I push the wall, the wall doesn't move but I slide backwards. The force I push on the wall is equal to the force the wall pushes on me, but opposite in direction.

eg. When you stand on the ground, gravity pulls you down(your weight, F_g or W) and you push on the ground. The ground responds with an equal and opposite force, the surface force F_s. Usually we look at the surface force as two forces, friction F_f (sideways sliding) and the normal force F_N (perpendicular to the surface).



The weight of force of gravity can be calculated by F_g=mg
eg. a 0.50 kg mass weighs
$F_g = mg = 0.50 \text{ kg} \times 9.80 \text{ m/s}^2$
F_g=4.9N

question: What factors influence the force of friction - force opposing sliding motion

coefficient of friction, μ, is the ratio of the friction force to the normal force.
Has no units.

$\mu = F_f/F_N$ = force you pulled/ weight on a flat surface

Block 2-2

eg. You pull a 1.00 kg cart with 2.00N of force.

a) if the cart is frictionless, what is the acceleration of the cart while you pull it?

$a = F_{net}/m \quad F_{net}=\Sigma F$

$a = 2.0N/1.0\ kg = 2.0\ m/s^2$

b) after you let it go?

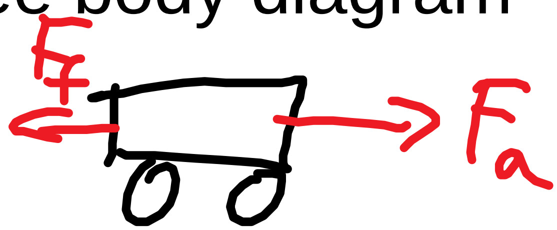
if it is frictionless, F=0 so the a=0 so it will roll until it hits something

c) if the force of friction is 0.50N,

i)what is the net force on the cart?

$F_{net}=\Sigma F$ a diagram of forces:

Free body diagram



$F_{net} = F_a - F_f$

$F_{net} = 2.0N - 0.5N$

$= 1.5N$

ii)what is the acceleration while you pull it?

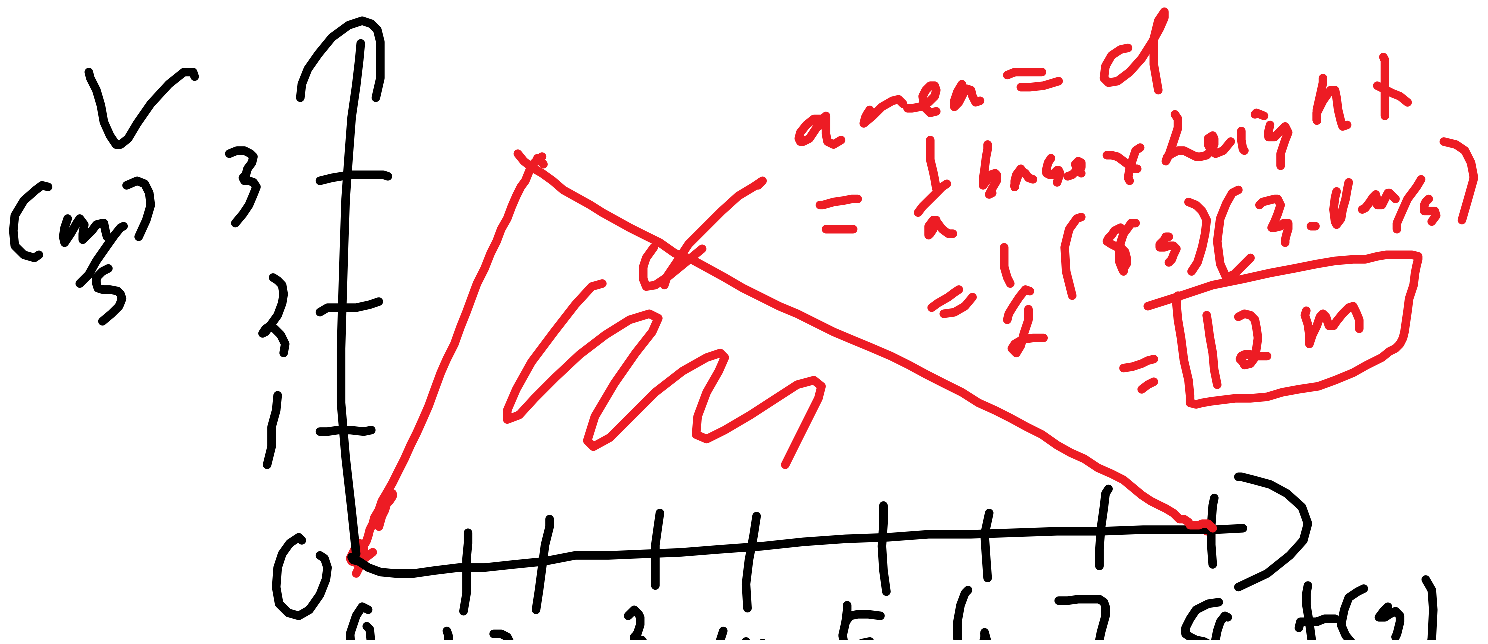
$a = \frac{F_{net}}{m}$

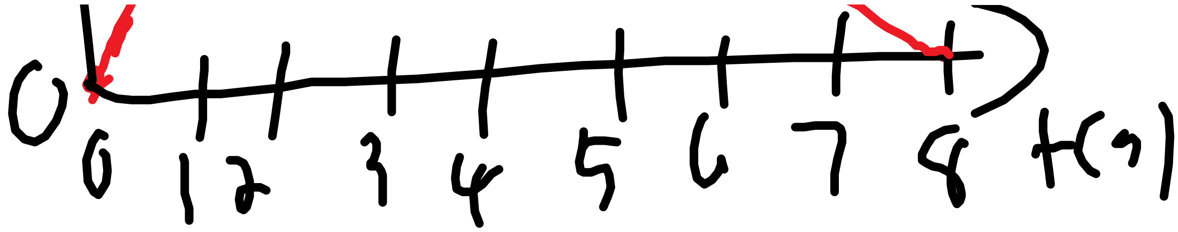
$a = \frac{1.5N}{1.0kg}$

a= 1.5 m/s^2

iii)After you let it go?
The only force is friction, so F_{net} = -0.50N
a=F_{net}/m = -0.50N/1.0kg = -0.50 m/s^2

iv)if you pull it for 2.0s, sketch the velocity-time graph and calculate the displacement until it stops.
v_i=0 v_f=? a= 1.5m/s^2 for the first 2 s , and a= -0.50 m/s^2 for the rest until it stops.
v_f= v_i+at = 0 + 1.5m/s^2 (2.0s) = 3.0m/s
for slowing down a=-0.50m/s^2 vi=3m/s vf=0 t=?
v_f= v_i+at 0=3.0m/s + (-0.50m/s^2)t
t=6.0s





Friction and Weight

Newton's Third Law - action-reaction
When an object exerts a force on another object, the second object exerts an equal but opposite force on the first.

eg. When I push on the table, I slide back because the table exerts and equal and opposite force on me.

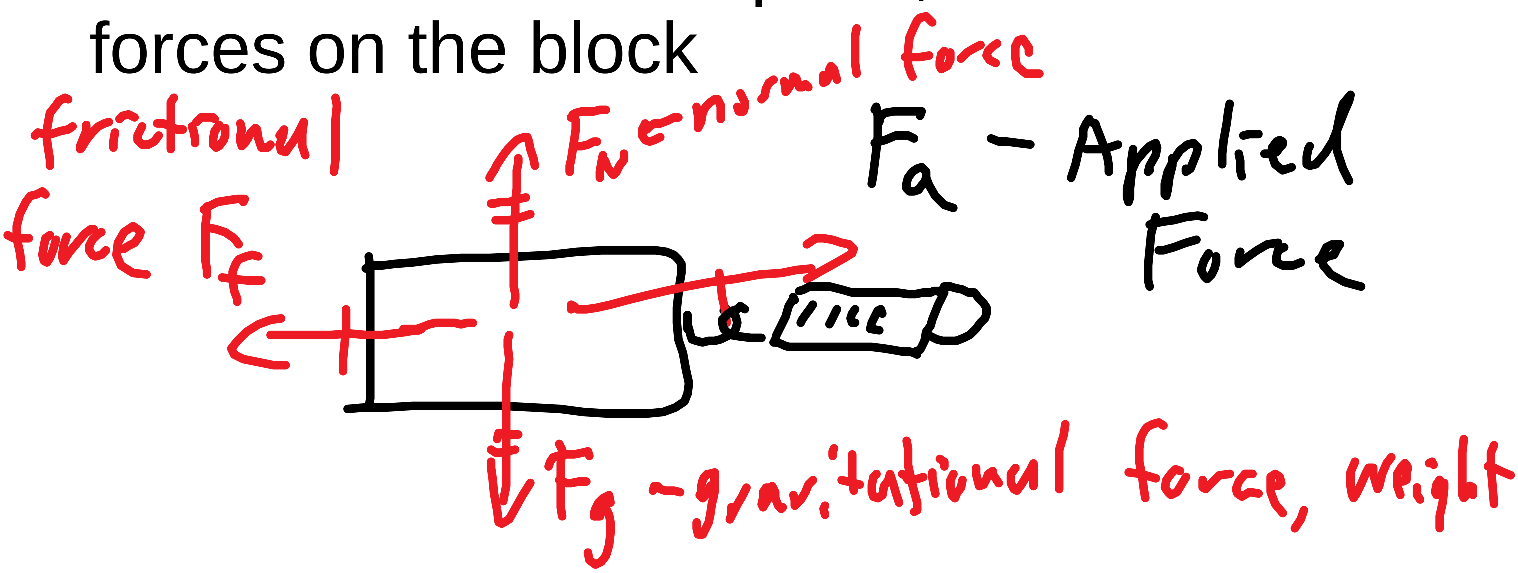
When I stand, I push on the ground so the ground pushes on me.
The force of gravity pulling me down is also called the weight. It is proportional to your mass.

Weight, W or F_g = mg where m is mass in kg and g is gravitational field strength,

=9.80N/kg near Earth

eg. a 0.50 kg mass weighs
$F_g = mg = (0.50kg) \times 9.80N/kg$
$= 4.9N$

Lab: Friction
When you pull a block using a spring scale at a constant speed, draw the forces on the block



if a = 0 , then $F_a = F_f$ and $F_N=F_g$ (on a level surface)
coefficient of friction, μ, is the ratio of the friction force to the normal force.
Has no units.

$\mu = F_f / F_N$ = force you pulled/ weight on a flat surface

Wednesday, November 18, 2015
12:33 PM

Dynamics (Chapter 5)

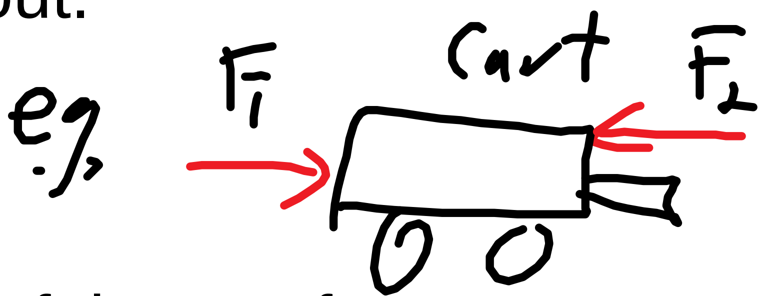
The study of why objects change motion - Forces.

Force is a push or a pull. Measured in units of Newtons, N.
$N = kg\ m/s^2$

Newton's 3 Laws of Motion:
Newton's First Law - Law of Inertia
Objects stay at the same speed and same direction (at rest or in motion) until an unbalanced force is applied.

eg. Coin on the card - pull the card away, the coin stays. It has inertia so the friction between the card and the coin is not enough to move it when you pull fast.
Inertia - tendency to not accelerate related to mass.
balanced force- the forces cancel each other

out.



If the two forces you push on the cart cancel out (same magnitude but opposite direction) then the forces are balanced and the cart keeps the same velocity.

If F_1 is greater than F_2, then it will accelerate in the direction of F_1.

What is the magnitude of the acceleration?
Newton's Second Law: Law of Acceleration
The acceleration of an object is proportional to the net force (vector sum of all forces) and inversely proportional to the mass.
$a = F_{net}/m$

net force is the sum of forces

$F_{net} = ma = \Sigma F$

sum of all

m is mass, in kg - the amount of matter.

a is acceleration in m/s^2 in the direction of the sum of all forces.

Why doesn't the cart roll forever?
Friction is a force that opposes sliding motion causing an acceleration opposite the direction of motion.

eg. You pull a 1.00 kg cart with 2.00N of force.

a) if the cart is frictionless, what is the acceleration of the cart i) while you pull it?

ii) after you let it go?

b) if the force of friction is 0.50N,

i)what is the net force on the cart?

ii)what is the acceleration while you pull it?

iii)After you let it go?

iv)if you pull it for 2.0s, sketch the velocity-time graph and calculate the displacement until it stops.

Block 2-2
Dynamics

The study of why objects change their motion (acceleration).

Force - a push of pull.
measured in Newtons, N
$N = kg \times m/s^2$

Newton's 3 Laws
demonstrations - coin on a card, cart and force scale, mass and a digital spring scale

The coin falls into the cup if you pull the card quickly, but moves with the card if you pull slowly.

What's going on?

Pull the cart with 1N, it accelerates.
if you pull with 2N it accelerates faster

If the cart fires a ball straight up, the ball falls back on the cart.

Newton's First Law- Law of Inertia
Inertia - tendency to not accelerate - depends on mass.
Objects will stay at the same speed and same direction unless unbalanced forces are applied.

F_{net} is the net force = vector sum of the forces

eg. force up - force down

balanced forces are when the opposite direction forces cancel each other out.

Newton's Second Law - Law of Acceleration
The acceleration of an object is proportional to the net force (sum of all forces) on the object and inversely proportional to mass.
$a=F_{net}/m$ sum

net force is sum of all forces

net force is sum of all forces

$$F_{net} = ma = \Sigma F$$

acceleration in m/s^2

mass, the amount of matter, in kg

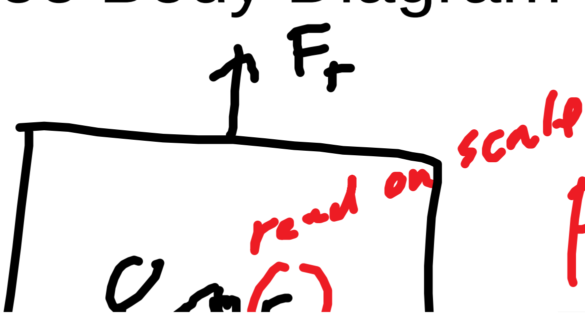
elevator problems and pulleys

1. Elevator problem:
You are holding a spring scale with a 0.50 kg mass on it, in an elevator. What does the spring scale read if:
a) you are not moving
b) you are moving up at 2.0m/s
c) you are accelerating up at 2.0m/s^2 for 3.0s.
d) you then come to a stop with uniform acceleration over 2.0s.
e) someone cuts the cable and the elevator falls freely

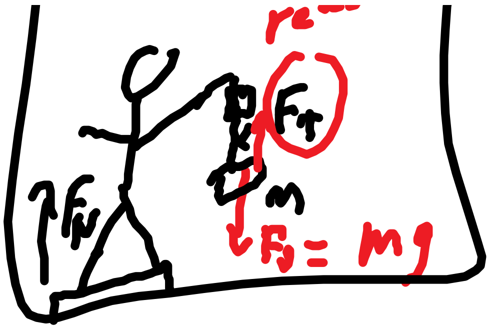
$F_{net}=ma=\Sigma F$

Free Body Diagram

up is positive



$F_{net} = \Sigma F = F_T - F_g$



$F_{net} = \Sigma F = F_t - F_g$

↑ include direction

$$ma = F_t - F_g$$

$$F_t = ma + F_g$$

↑ feel - apparent weight

2. pulley problems:

A 300g and a 200g mass are connected by a string over a pulley. When you let go, what is

a) the acceleration of each mass?

b) the tension in the string?

elevator problems and pulleys

1. Elevator problem:
You are holding a spring scale with a 0.50 kg mass on it, in an elevator. What does the spring scale read if:

a) you are not moving

$a=0$ so $F_t=F_g=mg=0.50kg x 9.80 N/kg$

$F_t=4.9N$

b) you are moving up at 2.0m/s

if v is constant, then

$a=0$ so $F_t=F_g=mg=0.50kg x 9.80 N/kg$

$F_t=4.9N$

c) you are accelerating up at $2.0 m/s^2$ for 3.0s.

$a=2.0\ m/s^2$

$F_t-F_g=F_{net} = ma$

$F_t = ma + F_g = ma + mg$

$= 0.50kg(2.0m/s^2) +4.9N$

$F_t = 5.9N$

d) you then come to a stop with uniform acceleration over 2.0s.

$vf = vi + at = 0 + (2.0 m/s^2)\ 3.0 s = 6.0 m/s$
after the acceleration you are moving at 6.0 m/s and come to a stop over 2.0s so the acceleration is
$a = (vf-vi)/t = (0-6.0 m/s)/2.0 s$
$a = -3.0 m/s^2$

so
$F_t - F_g = F_{net} = ma$
$F_t = ma + mg = 0.50 kg(-3.0 m/s^2) + 0.50 kg\ (9.80 m/s^2)$
3.4 N

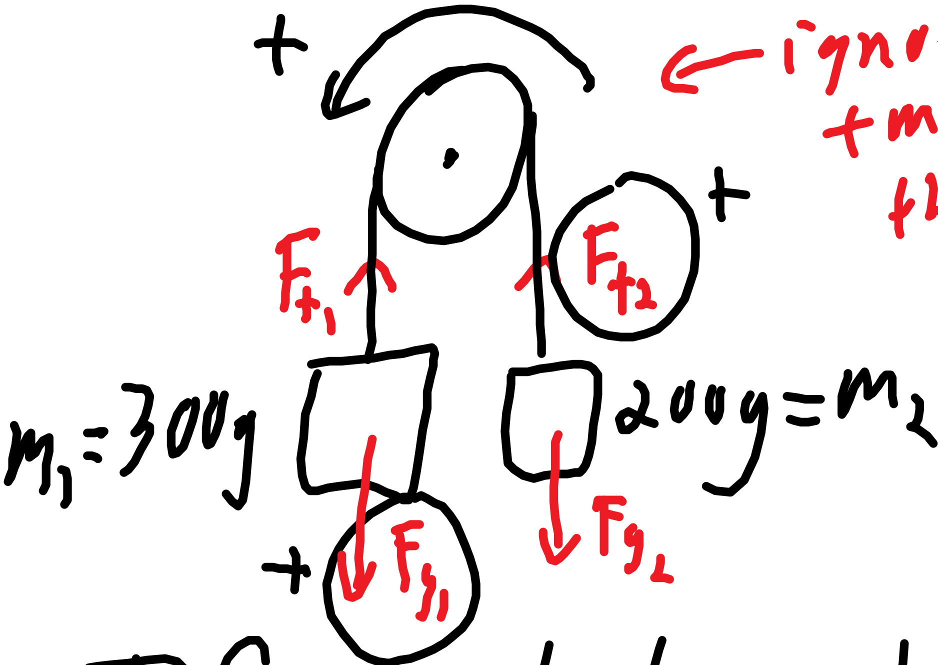
e) someone cuts the cable and the elevator falls freely
the scale is in freefall, so $F_t=0$ weightless

2. pulley problems:

A 300g and a 200 mass are connected by a string over a pulley. When you let go, what is

a) the acceleration of each mass?

b) the tension in the string?



← ignore friction + mass of pulley, then $F_{t_1} = -F_{t_2}$

If we look at the whole system

Cancel

$$+F_{g_1} - F_{T_1} + F_{T_2} - F_{g_2} = F_{net}$$

$$F_{g_1} - F_{g_2} = F_{net} = (m)a$$

whole system

$$m_1 g - m_2 g = (m_1 + m_2)a$$

$$a = \frac{(m_1 - m_2)g}{(m_1 + m_2)}$$

Pulley

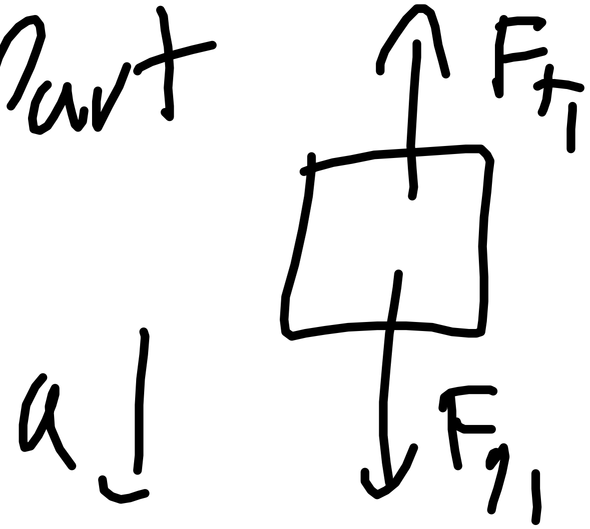
$$a = \frac{(0.30kg - 0.20kg)\, 9.8m/s^2}{0.30kg + 0.20kg}$$

$$a = 2.0 m/s^2$$

$d = \frac{1}{2}at^2$

$t = \sqrt{\frac{2d}{a}}$

Part

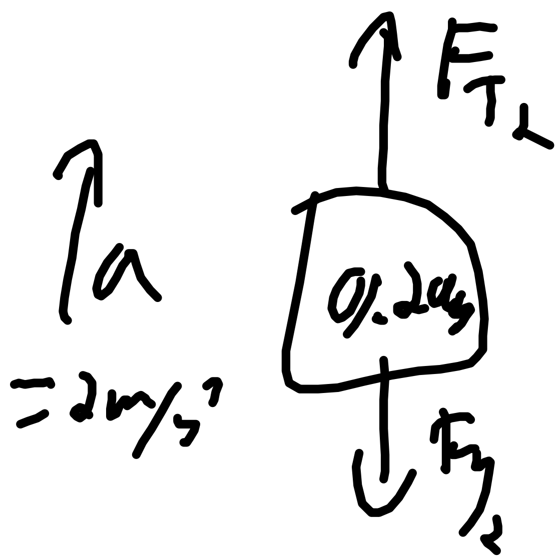


$$m_1 a = F_{g_1} - F_{T_1}$$

$$F_{T_1} = m_1 g - m_1 a$$

$$F_{T_1} = 0.3\,kg(9.8\,m/s^2) - 0.3(2)$$

$$= \boxed{\sout{2.34\,N}} \quad \boxed{2.3\,N}$$



$$m_2 a = F_{T_2} - F_{g_2}$$

$$F_{T_2} = m_2 a + F_{g_2}$$

$$F_{T_2} = (0.20\,kg)(2\,m/s^2) + 0.2\,kg(9.8\,N/kg)$$

$F_{T_2} = 2.3 \text{ N}$

Thursday, November 26, 2015
1:17 PM

Universal Gravitation (chapter 8.1 only)

What is gravity?

History

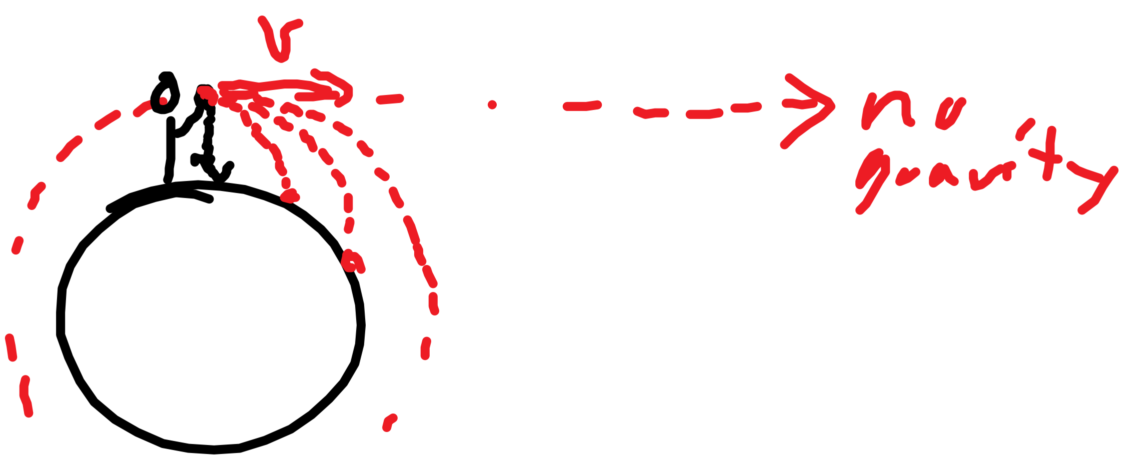
Aristotle (300BC) ancient Greece - everything is made of Earth, air, fire and water

theory - stuff with more earth or water goes down more,

Galileo (around 1600) - found that stuff fell at the same rate regardless of mass (Aristotle was wrong)

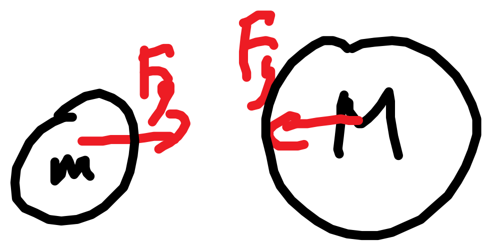
Newton - apple fell and he thought - "Hey, why doesn't the moon fall on my head?"

- The moon is falling but is moving fast enough to miss the Earth as it falls.



If you drop something if falls down.
If you throw something, it falls in a parabolic path.
If you throw it fast enough, it will fall along the curvature of the Earth - orbit.

Newton's Theory - every mass attracts every other mass.



$F_g = GMm/r^2$

F_g is the force of gravity pulling M and m together, in Newtons, N.
M and m are any two masses, in kg.
r is the distance between the centre of the masses, in metres, m.
G is the universal gravitational constant $6.67 \times 10^{-11}\ Nm^2/kg^2$ everywhere in the universe.

Einstein - yesterday was the 100th

anniversary of his theory of gravity - gravity causes warping of space-time.\

for next class
p163 CR 1.1-.14 p172 Problems 7,8,12
review for test:
p106 problems 4, 6, 8, 10, 11, 16, 17, 20
p107 22, 23, 26, 28, 29

p172 Q7

p172 Q7

F_g=GMm/r^2
= 6.67 x 10^{-11} Nm^2/kg^2 (1.99 x 10^{30}kg)
x (1.90 x 10^{27} kg)/ (7.781 x 10^{11}m$)^2$
= 6.67E (Exp, EE) -11 calculator
4.17 x 10^{23}N

Q8 F_g=GMm/r^2 =
= 6.67 x 10^{-11} Nm^2/kg^2 (70kg) x (50kg)/
(20m$)^2$
= 5.84 x 10^{-10}N

Q 12

P106 Q4,6,8,10,11,16,17,20
p107 Q22,23,26,28,29
Force -
Newton's 3 laws
F_{net}=ma=ΣF - free body diagram of forces
weight = F_g=mg near Earth g=9.80N/kg

$F_g = GMm/r^2$ if you get far from Earth

$F_f = \mu F_N$

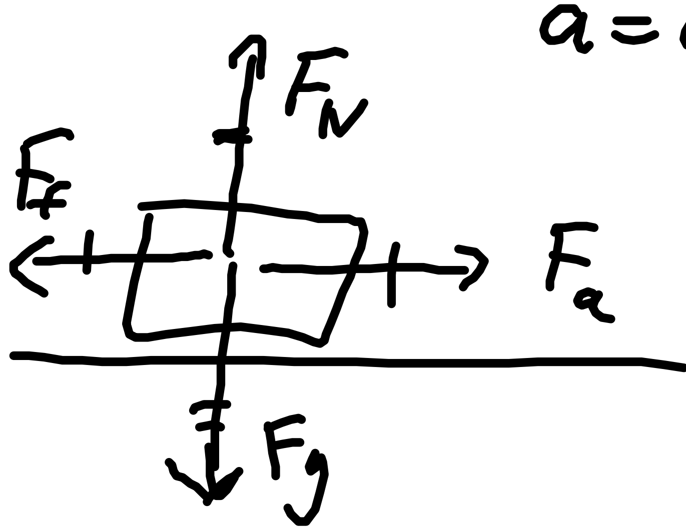
μ is the coefficient of friction - depends on the surfaces

tension is the force at each end of a string or cable

Quiz

$a = 0$

1 a)



b) Weight = Force of gravity = F_g

$F_g = mg = 0.45\,kg \times 9.8\,N/kg$ (0.35 kg written above 0.45 kg)

$= 3.4\,N$

$4.4\,N$

$= 4.4\,N$

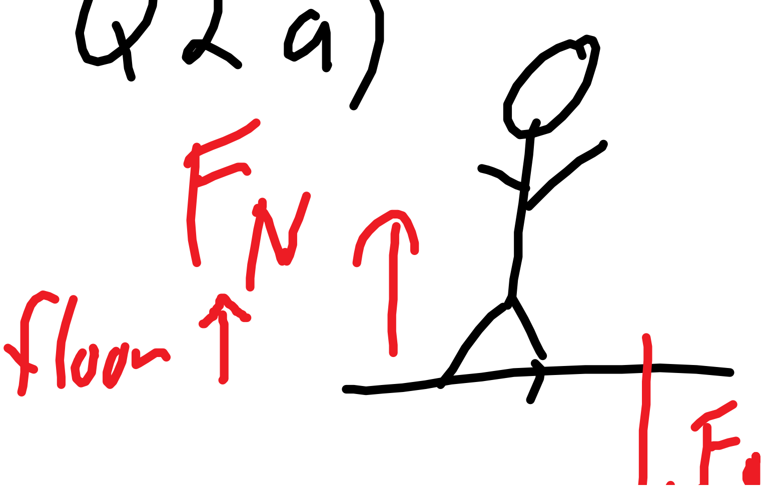
c) if $a = 0$ $\quad F_a = F_f = 1.5\,N$

$$\mu = \frac{F_f}{F_N} = \frac{1.5\,N}{3.4 \text{ or } 4.4\,N} = \begin{matrix} 0.34 \\ 0.44 \end{matrix}$$

d) $$a = \frac{F_{net}}{m} = \frac{F_a - F_f}{m}$$

$$a = \frac{3.0\,N - 1.5\,N}{0.45 \text{ or } 0.35} = \begin{matrix} 3.3\,m/s^2 \\ 4.4\,m/s^2 \end{matrix}$$

Q2 a)



↑ $a = 2.0\,m/s^2$

$\uparrow a = 2.0\,m/s^2$

$F_{net} = ma = \Sigma F$

$ma = F_N - F_g$

$F_N = ma + mg = \frac{45\,kg}{60\,kg}(2 + 9.8)$

$= 5.3 \times 10^2\,N$

$= 7.1 \times 10^2\,N$

b) $v = 2\,m/s$ so $a = 0$

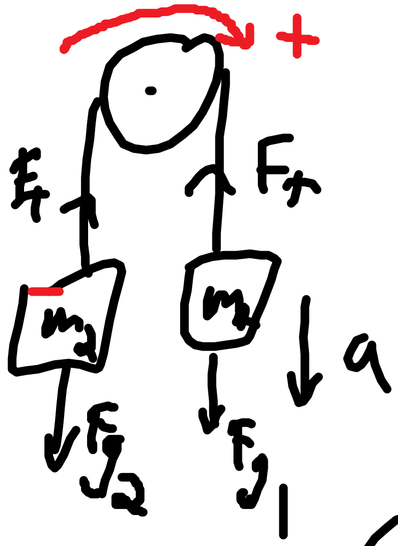
$F_N = \cancel{ma} + F_g$

$F_N = mg = 440\,N$ / $590\,N$

$F_N = mg = \boxed{590\,N}$

Q3 a)

a)



$$a = \frac{F_{net}}{m}$$

$$a = \frac{F_{g_1} - F_{g_2}}{m_1 + m_2}$$

$$(m_1 + m_2)a = m_1 g - m_2 g$$

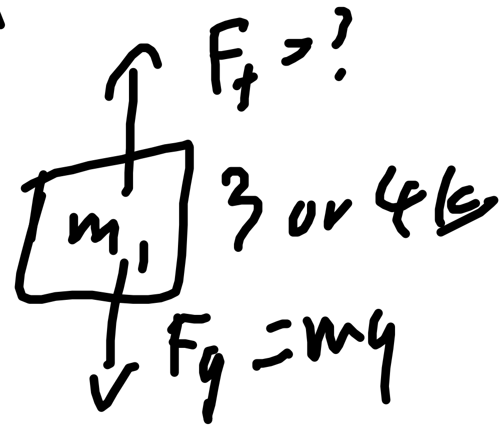
$$m_2 a + m_2 g = m_1 g - m_1 a$$

$$m_2 = \frac{m_1(g - a)}{g + a} \qquad a = 4 \qquad \frac{3(9.8 - 4)}{9.8 + 4}$$

$$m_2 = 1.7\,kg \text{ or } 2.1\,kg$$

b) $F_t = ?$

b)



$+\downarrow$ $\qquad \downarrow a = 4\,m/s^2$

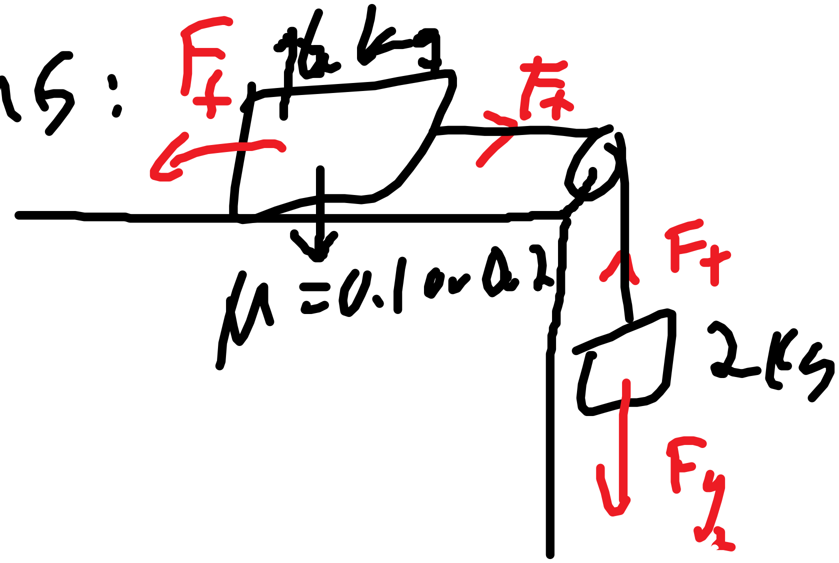
$$m_1 a = F_g - F_t$$

$$F_t = mg - ma = m(g - a)$$

$$F_t = (3 \text{ or } 4)(9.8 - 4)$$

$$= 23\,N \text{ or } 27\,N$$

bonus:



$F_{net} = \Sigma F = F_{g_2} - F_f = m_2 g - \mu m_1 g$

$= (m) a$ ← m total

$$a = \frac{2(9.8) - 0.1 \times 6 \times (9.8)}{2+6}$$

(0.1 is also written as 0.2 in the numerator.)

$a = 1.0\ m/s^2$ or $1.7\ m/s^2$